Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

FEBRUARY, 1955

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TECHNOLOGY DEPT.

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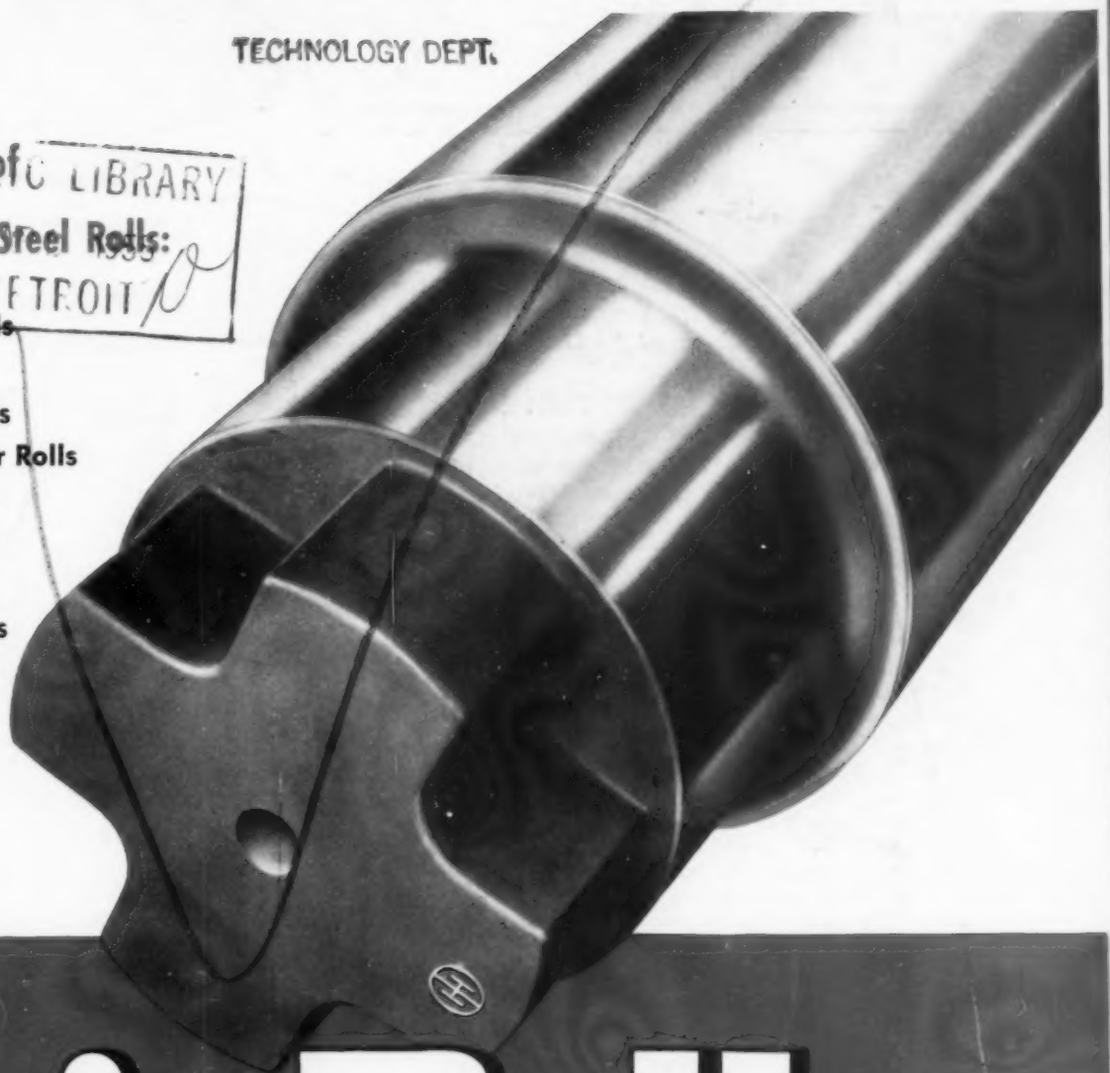
Choose from 11 types of
Ohio Iron and Steel Rolls:

- Carbon Steel Rolls
- Ohioloy Rolls
- Ohioloy "K" Rolls
- Ohio Double-Pour Rolls
- Holl-O-Cast Rolls
- Chilled Iron Rolls
- Denso Iron Rolls
- Nickel Grain Rolls
- Special Iron Rolls
- Nioloy Rolls
- Flintuff Rolls



Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY

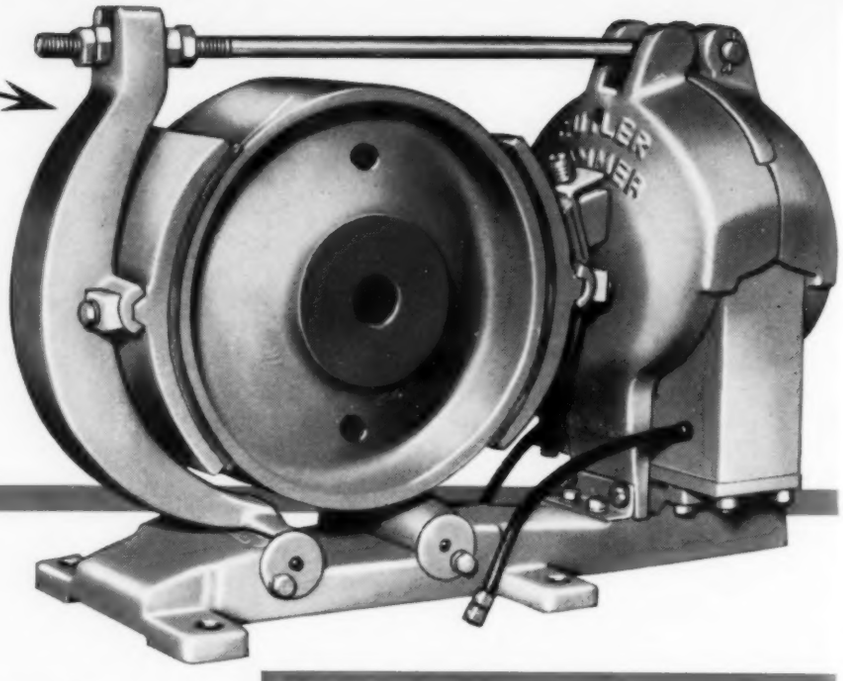
THE OHIO STEEL FOUNDRY CO.

LIMA, OHIO • PLANTS AT LIMA • AND SPRINGFIELD, OHIO

THE

NEW

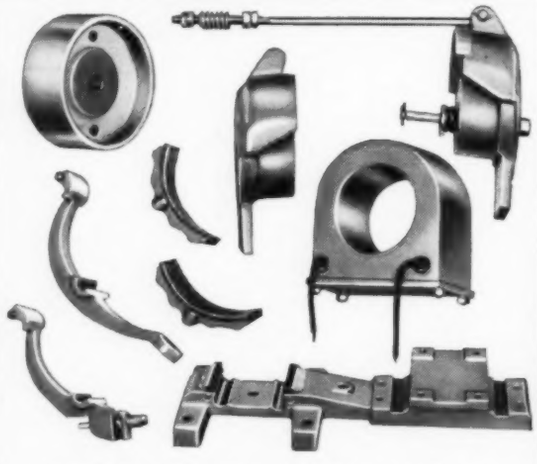
CUTLER-HAMMER BULLETIN 505 AISE MILL BRAKE



It stands alone for simplicity, dependability, durability and ease of maintenance

This is an amazing new brake, amazing in its simplicity, accessibility to all parts, ease of maintenance, durability and dependability . . . all the qualities that mean so much to mill operating personnel. It fully complies with new NEMA Standard and AISE Standard No.11 of Sept. 1952. It has a minimum of parts with direct, simple operating design. Troublesome pivot pins have been eliminated. In their place, oversize bearing surface joints and sockets are used which reduce bearing pressures to a fraction of any other mill brake. The new weatherproof capsule coil easily inserts as a unit between the two armatures and as easily removes as a unit. Out-of-action time is reduced to the period required to get a replacement coil from stock and bolted into place. Two movable armature members move the brake shoes, one directly, the other by means of the efficient, C-H originated over-the-wheel pull rod. This construction transmits braking force directly and eliminates bell cranks, cantilevers, and other troublesome means of transmitting power around a corner. It permits the shortest stroke, the most efficient braking action of all. Shoe travel is adjusted independently while the torque is set at a definite value; all segments of shoes travel at right angles to wheel circumference. These features remove the possibility of lining drag and excessive wear. Wide adjustment range facilitates ease of installation and alignment of brake with respect to motor. Shoes can be removed while wheel is running. The entire brake is disassembled and reassembled, easily, with the use of one wrench.

There are too many outstanding features to be covered on this page . . . features that *do* make this brake *the* brake of your choice. Write for complete descriptive literature and see why this should be your next brake buy. Write today . . . CUTLER-HAMMER, Inc., 1255 St. Paul Avenue, Milwaukee 1, Wisconsin. *Associates:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.



THESE ARE THE SIMPLE, CLEAR, OBVIOUS ADVANTAGES OF THE NEW C-H BULLETIN 505 BRAKE

1. Built to new AISE and NEMA Standards.
2. Simplicity and ruggedness apparent at a glance.
3. Direct action over-the-wheel construction for maximum braking effectiveness. The only brake with one to one ratio leverage.
4. Oversize bearing surfaces that with over-the-wheel pull rod cut bearing pressure and wear to a fraction of that of any other brake.
5. Weatherproof capsule coil bolted to base between two movable armatures. Easily removed as a unit, easily replaced as a unit. Reversible too.
6. There are but two simple adjustments. "Feel" type sounding pins tell easily and surely when to make adjustment—*and when adjustment is correctly made.*
7. The brake that retains the fundamental principle that for decades has made the Cutler-Hammer Mill Brake the standard of the industry.

CUTLER-HAMMER
MOTOR CONTROL
C-H

IRON AND STEEL ENGINEER; published monthly by Association of Iron and Steel Engineers, 1010 Empire Bldg., entered as second class matter January 25, 1924 at Pittsburgh, Pennsylvania under Act of Congress, March 3, 1879. $7.50 per year in United States and Canada, $10.00 foreign countries. Volume 32, No 2.

where

goes

AMERICA?

★ America must modernize its cities to keep up with a population growth estimated at 180 million by 1960. Every month we add to our population the equal of an Omaha, Nebraska; a Norfolk, Virginia; or a Toledo, Ohio.

Large scale building requires great tonnages of steel, copper, brass, aluminum, other metals, rubber and plastic. For example, a new office building under construction in New York will require 750 tons of sheet and strip for the air conditioning ducts alone. A remodeling of a Y. M. C. A. in our vision is taking 225 tons of steel. How much building is ahead? The year 1954 was the largest in history . . . 1955 is expected to be better.

Are your plants ready for volume production or are you handicapped by old equipment? **New equipment brings down production costs.**

Continuous Galvanizing obsoletes older methods. Aetna has installed 20 Continuous Galvanizing Lines and is constructing numbers 21 and 22. Will number 23 be yours? Other major Aetna products include Pipe and Tube Mills, Rolls, Flat Rolled Finishing Equipment, Drawbenches and related Cold Draw Equipment; Machinery for Rubber and Plastic.

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

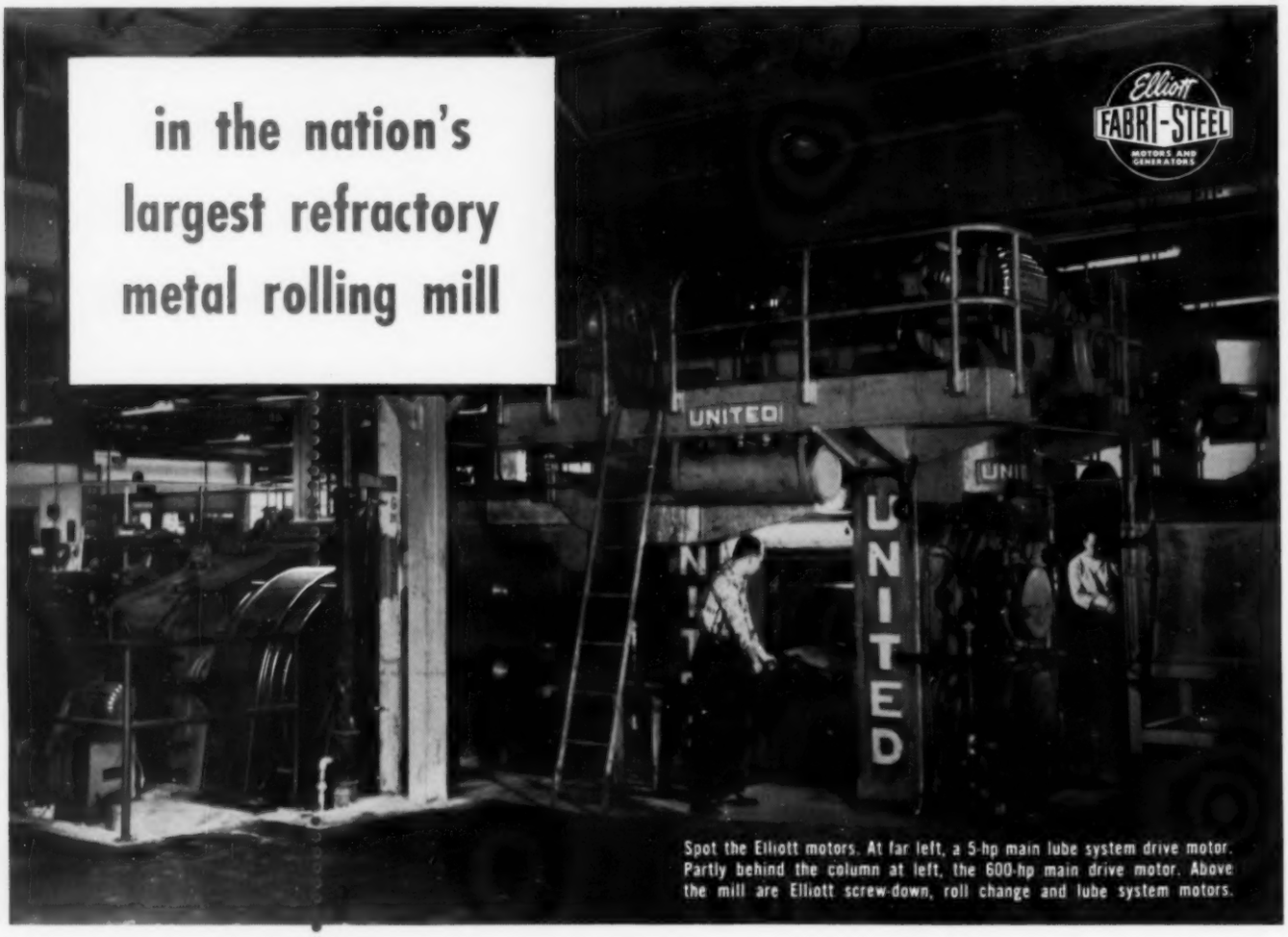
THE AETNA-STANDARD ENGINEERING COMPANY · PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO · ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

in the nation's largest refractory metal rolling mill



Spot the Elliott motors. At far left, a 5-hp main lube system drive motor. Partly behind the column at left, the 600-hp main drive motor. Above the mill are Elliott screw-down, roll change and lube system motors.

The Elliott 600-hp main drive motor. It is a four-speed, constant horsepower, two-winding, consequent pole squirrel-cage induction motor which develops not less than 250 percent pullout torque at all four speeds.

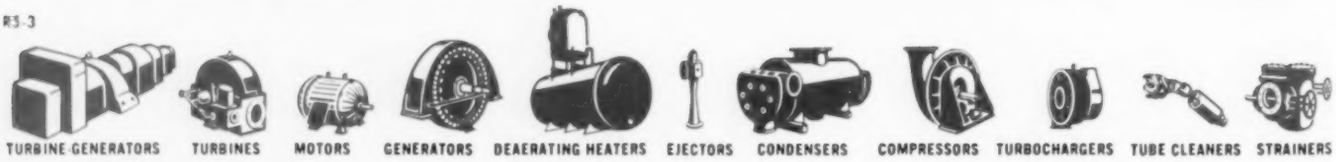
ELLIOTT MOTORS

Fansteel Metallurgical Corporation's modern, new 26 in. by 36 in. rolling mill provides greatly increased manufacturing capacity for such metals as tantalum, tungsten and molybdenum. Elliott motors furnish power at key points throughout the mill.

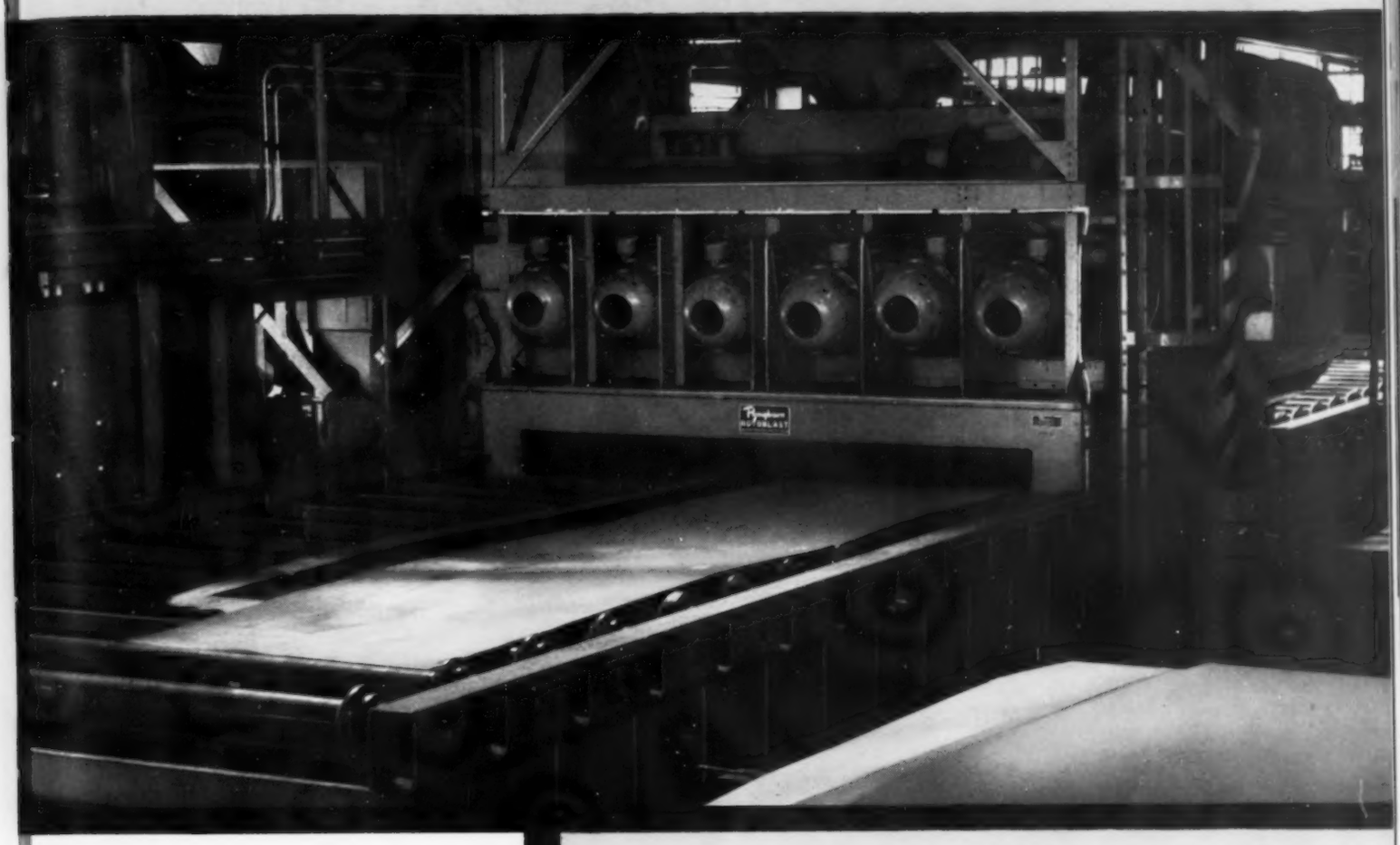
Largest of these is an Elliott 600 hp main drive induction motor which can be operated at four speeds, forward or reverse—450, 600, 900 or 1200 rpm. Pushbutton control is also provided for inching or jogging. The control is electrically interlocked so that the mill does not start until the oil pumps are running and oil pressure is normal. In addition, a number of Elliott Crocker-Wheeler 15 hp and smaller motors are on auxiliary drive service. Elliott motors are at home in metal mill service. Their rugged construction, careful design and dependable operation assure the highest standards of performance. Elliott Company, Ridgway Division, Ridgway, Pa.

ELLIOTT Company

RS-3



Descale steel sheets, plates, coils



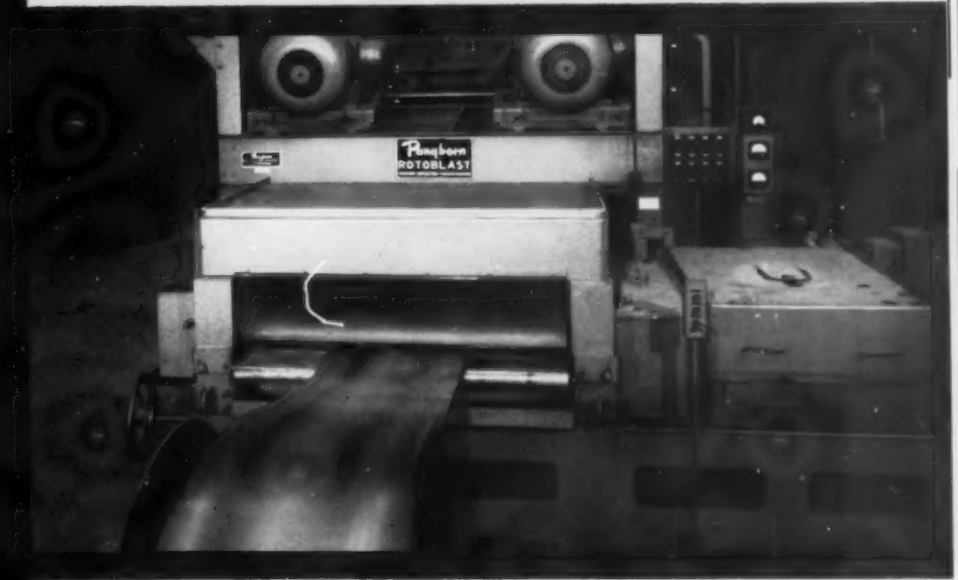
at *less than half the cost*

No more scale breaking or pickling! No more acid disposal problems! Pangborn Rotoblast Descaling Machines descale steel sheets, plates and coils, and they operate at big savings over pickling costs!

How? They work quickly. They clean thoroughly. They're a one-man operation. Unlike acid baths, they can be located near your production, cutting handling costs. And they save floor space, require much less room than vats. Available in a variety of models, Pangborn Rotoblast Descaling Machines handle steel sheets, plates and coils of any thickness, width and length. If you want to cut descaling costs to the bone, investigate Pangborn Descaling Machines!

For complete information, send for Bulletin 224. Write: PANGBORN CORPORATION, 4400 Pangborn Blvd., Hagerstown, Maryland.

*U. S. Pat. #2184926 (other patents pending)



with Pangborn Rotoblast® Descaling Machines!

Pangborn

BLAST CLEANS CHEAPER

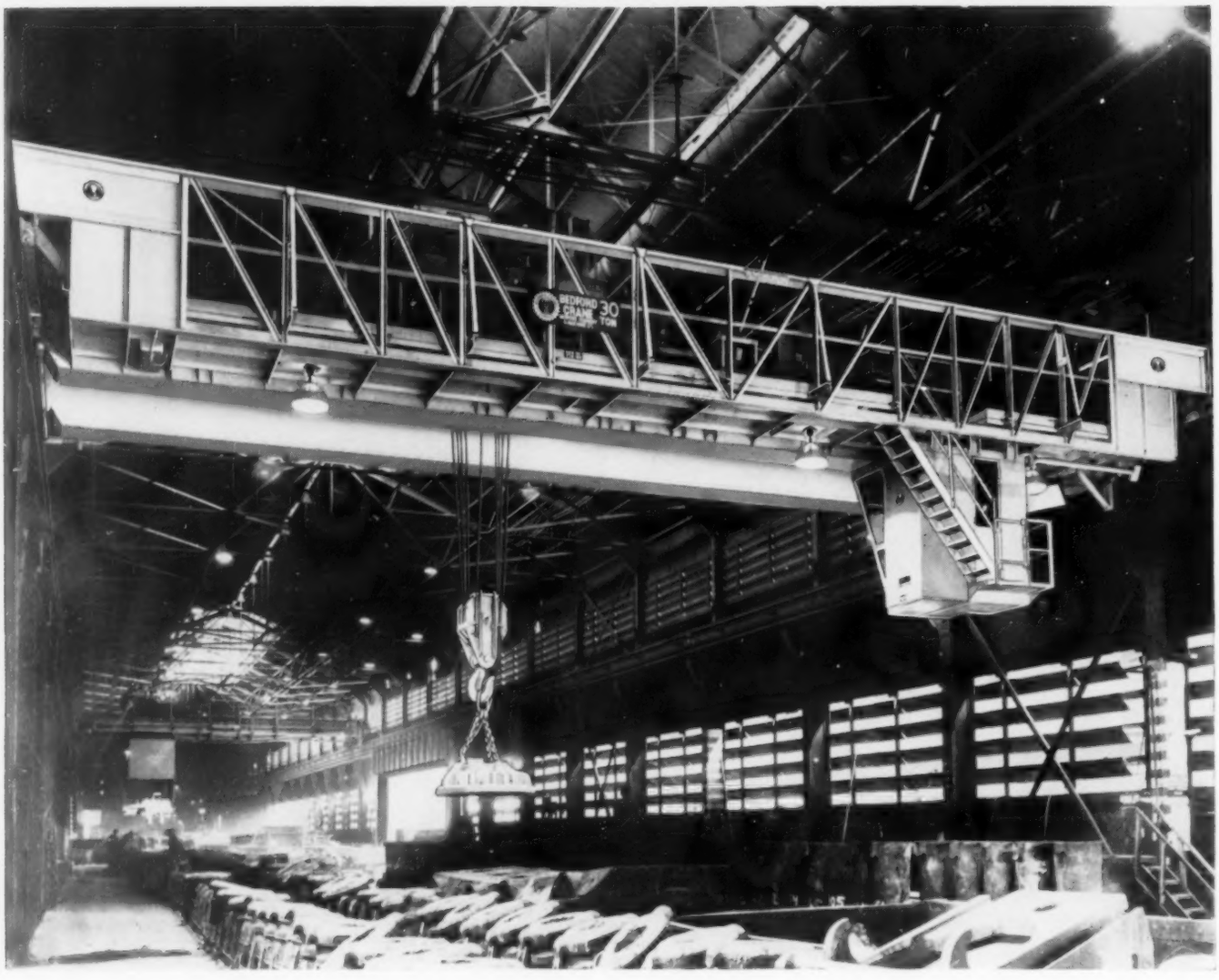
Rotoblast Blastmaster® & Continuous-Flo Barrel

Rotoblast Tables & Table-Rooms

Special Blast Rooms & Cabinets

Pangborn Dust Control Equipment

Malleabrasive* Shot & Grit



Another Bedford Mill Type Crane at Timken Roller Bearing Company

The Timken Roller Bearing Company has just installed a new 30-ton Bedford crane over the stripper building in their mill at Canton, Ohio. This is the second Bedford crane to be installed by the Timken Roller Bearing Company at Canton since July, 1952. The new crane has a 61′2″ span with 32′5″ lift. Built to AISE specifications, it has air-conditioned cab, worm drive gear on the hoist, and welded girders.

Proof of the superiority of Bedford cranes is found in the high percentage of repeat orders from important owners through the years.

Available in all types and sizes . . . from 5 tons to 350 tons, and up, for all kinds of indoor and outdoor services . . . each Bedford crane is individually engineered and precision built for its specific application.

Built to the most modern standards and backed by more than 52 years of specialized crane building and *utilization experience* . . . Bedford cranes have won fame the world over for advanced design—and for safe, smooth, more dependable performance.

You are invited to consult a Bedford engineer on your next crane problem . . . with all the facts on the table we believe you too will make your next crane a Bedford.

(Write for complete catalog describing Bedford Cranes in detail.)

BEDFORD CRANE SERVICE

STEEL MILL CRANES

BEDFORD

New York Office: 30 Church St., Room 426
New York 7, N. Y., Phone COrtlandt 7-1896

Pittsburgh Office: Oliver Building, Room 1241
Phone ATlantic 1-0136

BEDFORD FOUNDRY & MACHINE COMPANY, INC. • BEDFORD, INDIANA

STOP CRANES SAFELY with EC&M

DYNAMIC BRAKING BRIDGE-STOP CONTROL

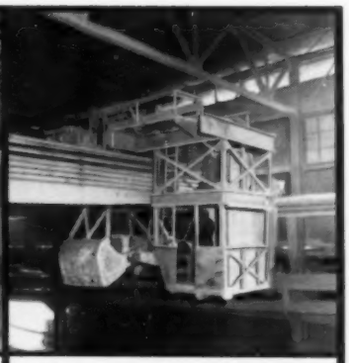
POSITIVE STOPPING by the same motors that drive the crane . . . even when power fails or overload relays trip.

Now . . . collision between cranes, crashing into the end-bumpers, and wheel-sliding stops can be avoided by the use of simple equipment. Crane motors are automatically converted into self-excited generators by this EC&M Bridge-Stop Control to provide quick, positive stopping. Transition to dynamic braking occurs instantly on power failure or when overload relays trip. Braking is not dependent on an outside source of power.

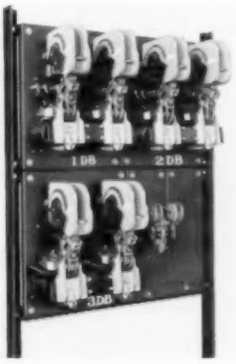
This EC&M system of control is fast and equally effective when traveling in either direction. Graduated braking is maintained throughout the entire stopping period by a pulsating spring-closed contactor . . . an exclusive EC&M feature. On icy, slippery rails, wheels do not slide to a stop . . . instead, this system automatically releases and then re-applies retardation to give a quicker stop than when the wheels remain locked.

EC&M Dynamic Braking Bridge-Stop Control is easily applied to new and old cranes to provide power-failure emergency operation. It is also designed for service-braking operation which is selectively applied by the operator or end-zone limit switches.

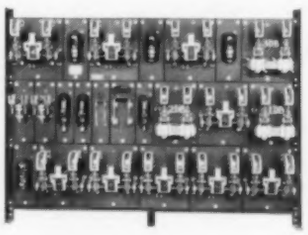
Eliminate hazards due to slippery rails . . . inability of operator to reach foot-brake in time when power fails.



Obtain smoother, safer operation when you change over to EC&M Dynamic Braking Bridge-Stop Control.



For existing installations, this panel provides graduated dynamic braking for quick, sure stops.



Complete Duplex (2-motor) Controller including EC&M Dynamic Braking Bridge-Stop Control.

6149

Write for Bulletin 921-6.0

THE ELECTRIC CONTROLLER & MFG. CO.
2698 East 79th Street • Cleveland 4, Ohio

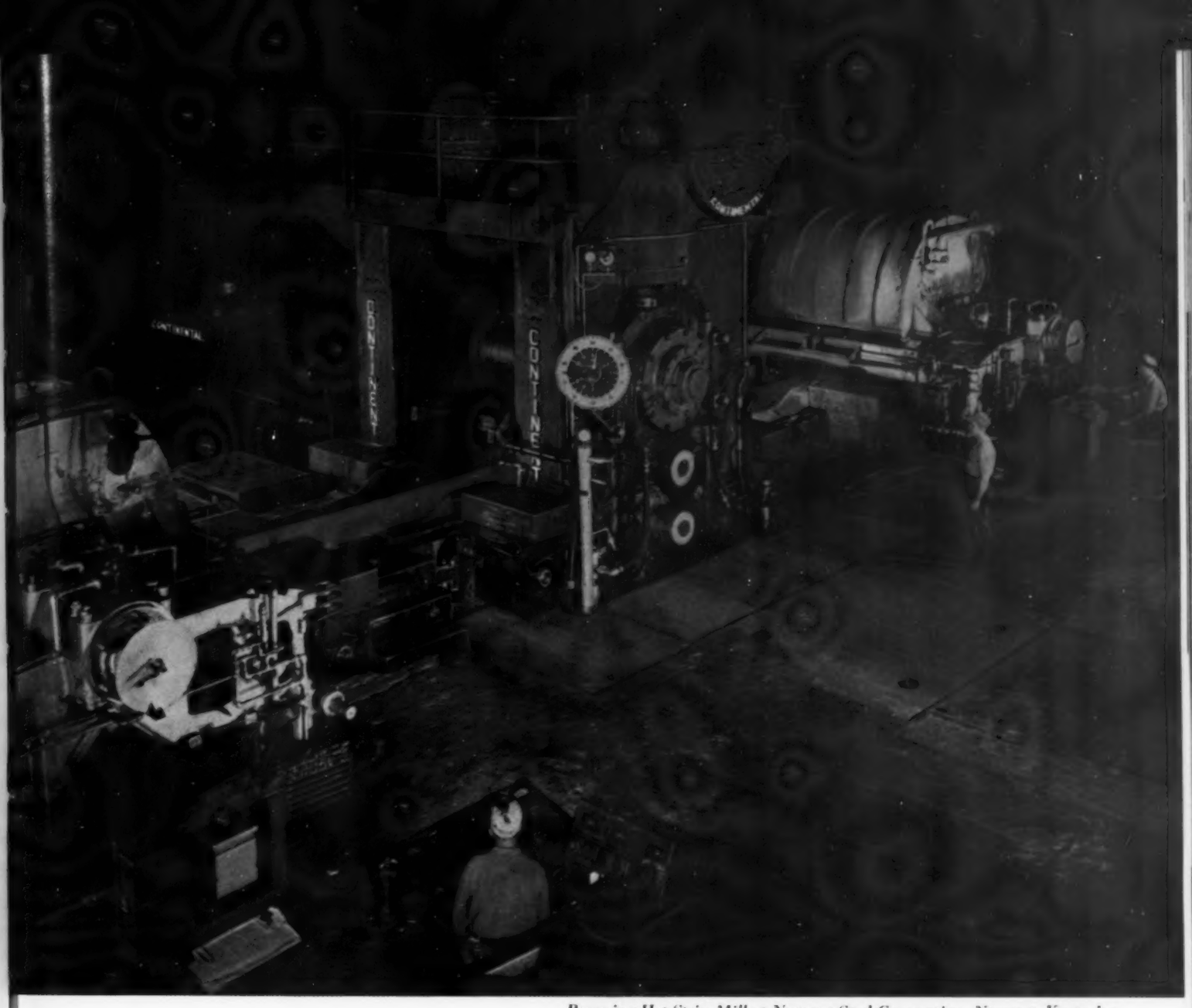
Here's the Most Famous Industrial Heating Element Marketed Today . . .

The Lee Wilson "O" Tube

More metal tonnage is annealed by radiant tubes than by any other method, and the most efficient radiant tube is the popular Lee Wilson "O" Tube.

Designed by the company that pioneered radiant tube annealing, the "O" Tube has no equal when it comes to speed, control and useful life. Its development was responsible to a great degree for making the Lee Wilson Single-Stack the fastest selling sheet and strip annealing furnace on the market today.

LEE WILSON ENGINEERING COMPANY, INC. • 20005 West Lake Road, Cleveland 16, Ohio



Reversing Hot Strip Mill at Newport Steel Corporation, Newport, Kentucky

Precision hot strip direct from ingots

This Continental 66-inch four-high Reversing Hot Strip Mill is designed for the production of precision-gage hot strip by direct reduction from the ingot in a continuous operation. This installation is suitable for production of all grades of steel. Mill size is 26″ x 49″ x 66″, driven by a reversing motor through a pinion stand, single motor drive. It also is equipped with motor driven screw-downs providing full range speed regulation and hydraulic roll balance. Continental's rolling mill installations include every step from initial engineering to satisfactory operations.

CONTINENTAL

Engineering and Sales Office, 220 Grant St., Pittsburgh 19, Pa.
***Plants at* East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.**
***Copes-Vulcan Division*, Erie, Pa.**

CONTINENTAL
Foundry & Machine
Company

Billet Peeling pays dividends!

Carbon, Alloy or Non-ferrous

This Continental-Medart billet conditioning process pays dividends in speedy operation and complete recovery of metal.

Billet peeling—as compared with scarfing or pickling—ends problems of air and river contamination . . . eliminates burning, and salvages all waste metal for remelting. The Continental-Medart method is the fastest billet peeling operation, ranging from 1 to 40 feet per minute throughput. The operation can be arranged for close surface control or deep, hogging cuts on diameters from 3″ to 33″.

Continental-Medart has built the largest Billet Peeler in existence and regularly produces a full size range. When your operations call for fast, accurate billet conditioning, call in your Continental-Medart representative.

Continental Building
220 Grant Street, Pittsburgh 19, Pa.

Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.
Copes-Vulcan Division, Erie, Pa.

CONTINENTAL
Foundry & Machine
Company

Get Extra Sub-hearth

SAFETY AND LONGER LIFE

with Permanente Periclase D-S Brick

THIS superior brick has been *especially designed* to withstand sub-hearth conditions. Thus, it gives maximum protection against costly breakthroughs and provides longer sub-hearth life.

All the important properties outlined by major steel company ceramists as most desirable for sub-hearth brick are found in Permanente Periclase D-S Brick.

High MgO (more than 95%) is achieved through the use of pre-shrunk, accurately-sized Periclase grains derived from sea-water magnesia. Absence of chrome eliminates the reduction of chromium oxide and damage to the refractory structure.

Low iron content minimizes refractory damage from alternate oxidation and reduction of iron oxide and other iron compounds. Absence of calcium oxide prevents damage caused by slaking during slow heat-ups or while furnace is idle.

With all its many advantages, Permanente Periclase D-S Brick gives you the ultimate in sub-hearth safety and durability—*yet costs no more!*

Call or write Kaiser Chemicals Division, *Kaiser Aluminum & Chemical Sales, Inc. Regional Sales Offices: 1924 Broadway,* OAKLAND *12, California . . . First National Tower,* AKRON *8, Ohio . . . 518 Calumet Bldg., 5231 Hohman Avenue, Hammond, Indiana* (CHICAGO).

Permanente PERICLASE Brick for the Steel Industry:

- Permanente Periclase Brick (D-S)
- Permanente Periclase Chrome Brick (PCA)
- Permanente Chrome Periclase Brick (CPA)

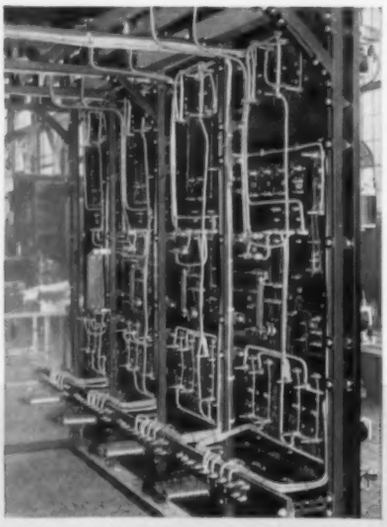
Now available! A companion mortar for Permanente D-S brick. High purity periclase composition *and* maximum workability.

Installation advice on request

Kaiser Chemicals

Pioneers in Modern Basic Refractories

Basic Refractory Brick • Ramming Materials • Castables & Mortars • Magnesite • Periclase • Deadburned Dolomite



Back of panel shows accessibility of terminal blocks and neat grouping of wiring.

ALLIS-CHALMERS

CONTROL

Modern

Constant Potential Panels for Top Efficiency and Low-Cost Operation

Steel mill control is an Allis-Chalmers specialty. That's why many mills and their consultants are turning to Allis-Chalmers for engineering help and the latest in control equipment . . . equipment like this constant potential panel for dc auxiliary drives. Operating under the roughest conditions, this unit is providing smooth, precision performance . . . affording maximum production and quality with a minimum of outage time and maintenance.

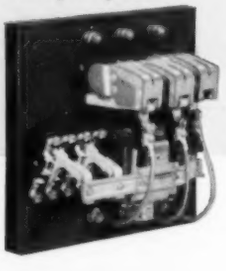
Constant potential and variable voltage systems, magnetic amplifiers, rotating, electronic and mechanical regulators, liquid rheostat — all engineered, built and applied by Allis-Chalmers — are building greater profits in modern mills. When you modernize to meet the double challenge of a growing market and heavy competition, take advantage of Allis-Chalmers experience. Call your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

A-4588

Type 260 Contactor

Quick-quenching arc-centering blowout solves problem of contact burning by sharply curtailing arcing time.

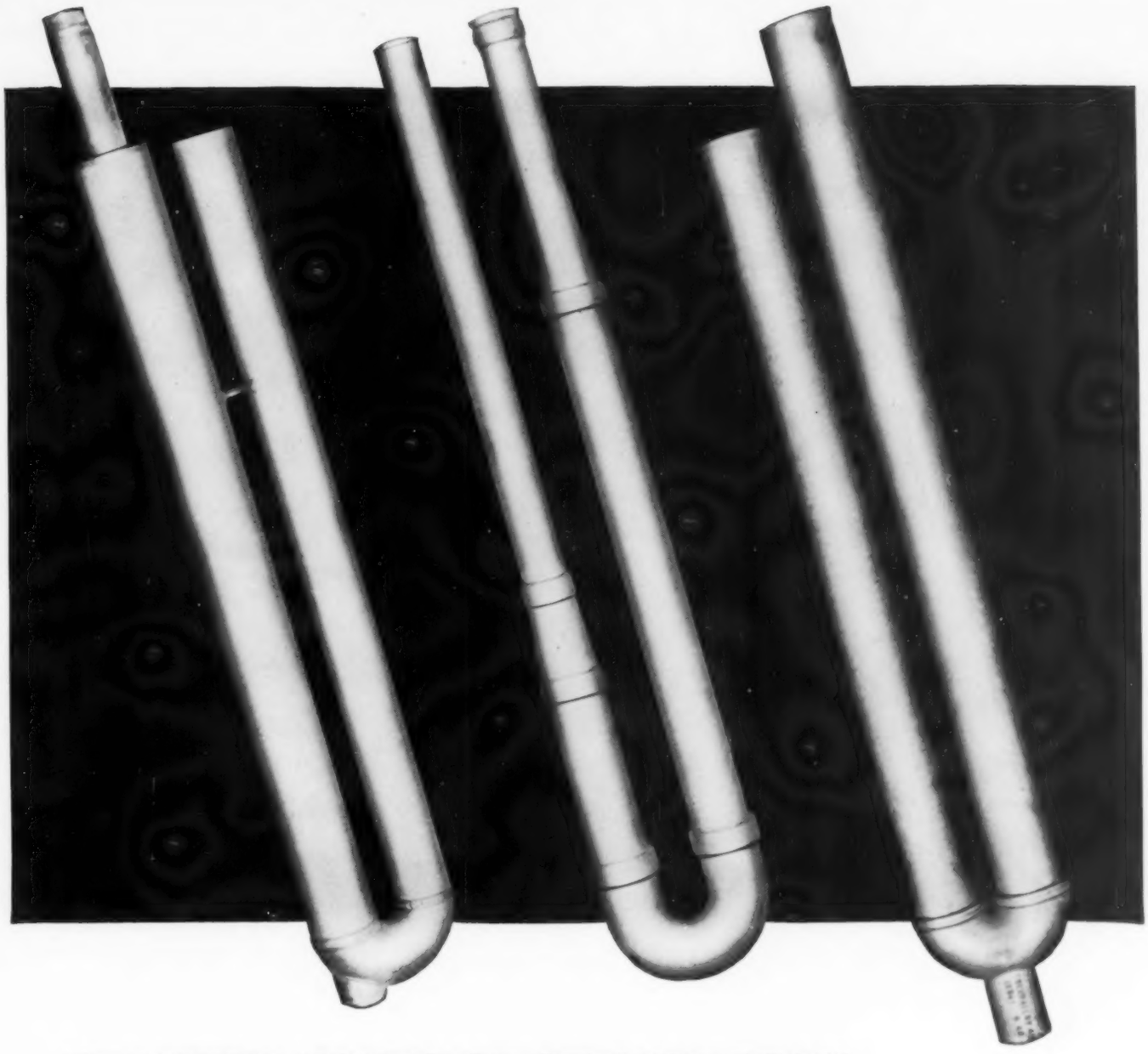
NEW heavy-duty Type 522 contactors and Type 521 relays feature exceptional interchangeability of parts.



Type 522 Contactor

A-C ALLIS-CHALMERS

ALLIS-CHALMERS



GET MORE HOURS OF SERVICE FROM

Thermalloy* radiant tubes

Make Electro-Alloys your source if you want radiant tube assemblies that will give more life and reduce maintenance costs.

All components are produced in suitable analyses under close metallurgical supervision, and with X-ray control. The straight tube sections are centrifugally cast in such a way that wall thickness is uniform throughout; i. e., inside diameter and outside diameter are concentric, and thickness is the same the full length of the tube. All finished assemblies are pressure-tested before shipment to insure freedom from leakage. As a result, you are assured of radiant tube assemblies that last longer without cracking, warping or sagging.

Whatever your needs in radiant tube assemblies or other heat-treating equipment—you'll get more operating economy from high heat-resistant Thermalloy castings. Let us know your requirements. Call your nearest Electro-Alloys engineer or write Electro-Alloys Division, 6004 Taylor Street, Elyria, Ohio.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

*Reg. U. S. Pat. Off

SEE RUST-OLEUM APPLIED DIRECTLY OVER SOUND RUSTED SURFACES! MAKE THIS TEST UNDER YOUR OWN CONDITIONS AND SEE PROOF OF PERFORMANCE!

See Rust-Oleum 769 Damp-Proof Red Primer actually applied over a badly rusted surface after simple scraping and wire-brushing to remove rust scale and loose rust in the Rust-Oleum *"rusted panel demonstration."* Rust-Oleum's specially-processed fish oil vehicle *penetrates* rust to bare metal usually eliminating sandblasting and other costly surface preparations.

Rust-Oleum finish coatings in Aluminum, Green, White, Gray, Yellow, Black, Orange, Blue and others provide both *Rust Prevention* and *Decorative Beauty!* Specify Rust-Oleum for new construction, maintenance, and re-modeling. See Sweets for complete catalog and nearest Rust-Oleum Industrial Distributor, or attach coupon to your business letterhead.

RUST-OLEUM®

STOPS RUST!

There Is Only One Rust-Oleum. It Is Distinctive as Your Own Fingerprint. Resists Rain, Sun, Fumes, Snow, Heat, Salt Air, Salt Water, etc.

See local classified telephone directory under Rust Preventives or Paints for nearest Rust-Oleum Industrial Distributor.

ATTACH TO YOUR BUSINESS LETTERHEAD AND MAIL TO:
Rust-Oleum Corporation, 2442 Oakton St., Evanston, Ill.

- ☐ Please Show Me the Rust-Oleum "Rusted Panel Demonstration."
- ☐ Test Application of Rust-Oleum Over Rusted Metal Surfaces in My Plant.
- ☐ Complete Literature with Color Chart.
- ☐ Nearest Rust-Oleum Industrial Distributor.

"Westinghouse furnaces stepped up our production"

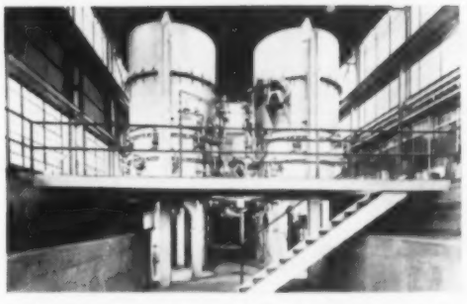
. . . says Thompson Wire Co.

Thompson Wire Co. is now using four *gas-fired* Westinghouse cylindrical bell-type furnaces, 12 bases, 12 inner hoods, and 8 air-cooling hoods. A fan, mounted on top of each cooling hood, draws air between the work hood and cooling hood, exhausting heated air to the top, thus accelerating cooling of the charge.

This entire new operation has given Thompson Wire Co., greater load per heat, faster cooling, less maintenance costs and increased production.

Investigate Westinghouse heat-treating furnaces with an eye toward cutting costs and increasing capacity.

For more information regarding Westinghouse heat-treating furnaces, write or call your nearby Westinghouse office. J-10439



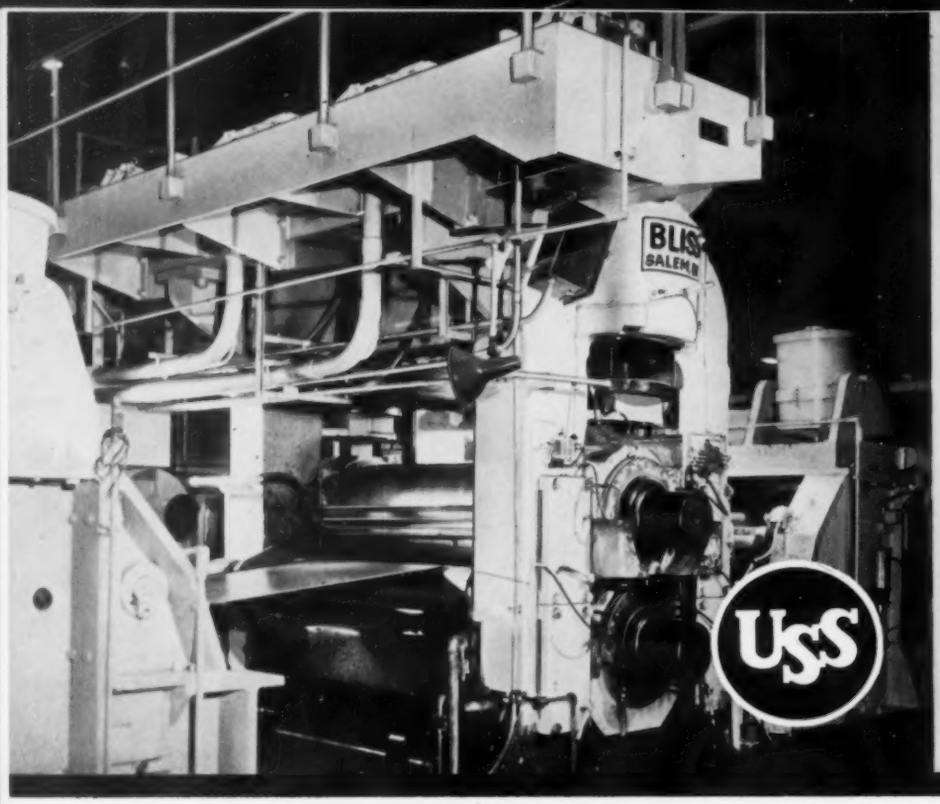
This sub-mounting of Westinghouse cylindrical bell-type furnace bases makes motors and controls easily accessible.

These pyrometers and mounting panels at the Thompson Wire Co. control and indicate furnace temperatures. Note alarm horns.

YOU CAN BE SURE...IF IT'S

Westinghouse

IF YOUR PRODUCT CALLS FOR HEAT-TREATING . . .
IT CALLS FOR A WESTINGHOUSE FURNACE . . . GAS OR ELECTRIC



"We want a faster pickle line"

This Bliss 32" x 80" Two-High temper mill at the entry end of the Fairless Works pickle line is new and unique to the steel industry. It reduces strip slightly (2 to 3% elongation) and pulverizes skin-tight oxides. Pickling acids attack surfaces faster, speeding the entire operation and making better, more uniform pickling possible. For the Fairless Works, Bliss also designed, built and installed an automatic 19" x 53" x 48" Two-Stand tin temper mill (needs only 3 men to operate it) and another 32" x 80" Two-High mill that eliminates an extra handling operation in tempering and flattening strip prior to shearing or slitting.

When you think of ROLLING MILLS— think of BLISS!

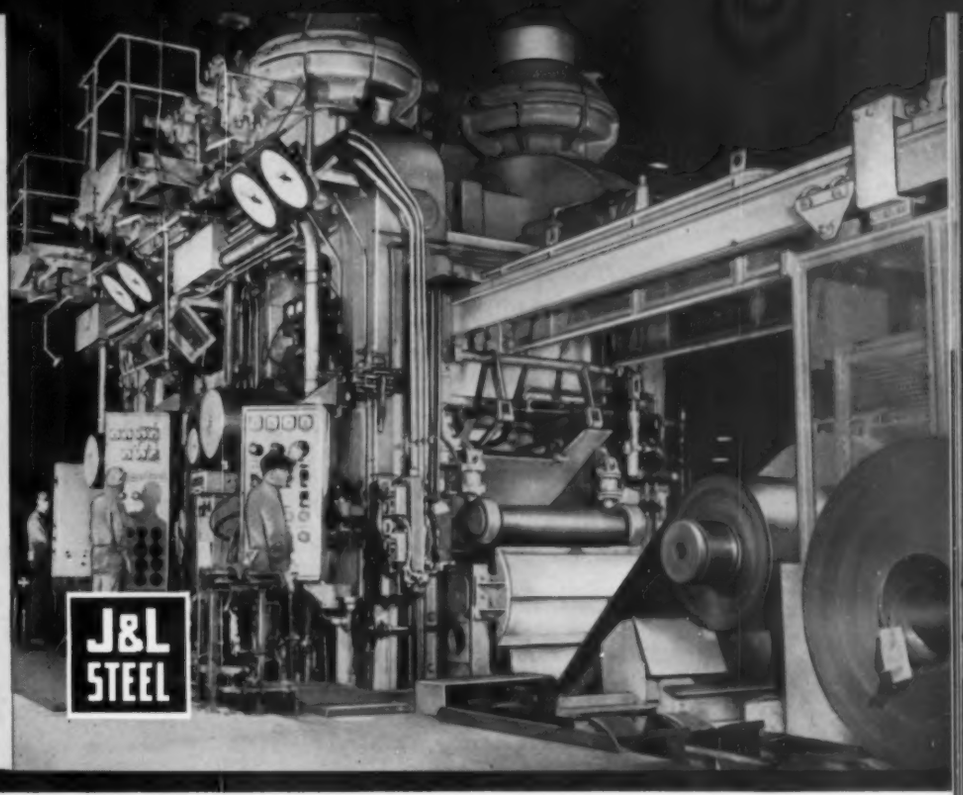
Here's the story of four who did

"Versatility . . . sheet-stock now, tinplate later"

At Pittsburgh Steel, this giant Four-Stand cold mill handles widths from 20 to 60 ins., thicknesses from tinplate to 16 gage. With its heavy housings it can also be set up to roll stainless. X-ray equipment spots variations in thickness as small as .0005" to permit immediate corrections. Other electronic devices control tension, shape and finish. Automatic coil handling equipment and the latest safety devices are used throughout. Bliss also installed a Four-High temper mill and a Two-High skin pass mill at the same Allenport, Pa. plant.

"We want speed throughout... in the mill and on coil handling, too"

By rolling more than 6000 fpm, this Bliss Two-Stand tin temper mill at Jones and Laughlin is one of today's fastest. These mile-a-minute speeds, though, called for a number of Bliss-developed design precautions: dynamic balancing of all rotating parts, gear-type couplings to assure uniform angular velocities. Moreover, semi-automatic terminal and auxiliary equipment—designed for extra large coils and quick strip threading—mean longer contact time, shorter loading periods and greater tonnage all along the line. Fast, reliable, safe, this Bliss mill is capable of better quality at higher speeds with easier control.



Whatever your problem in mills and accessories—speed... versatility... accuracy... in hot or cold rolling...ferrous or non-ferrous applications—whenever you think of rolling mills, think of BLISS.

For more information about others who thought of Bliss—for rolling mills and accessories—write today for Catalog 40-A. This 60-page brochure describes Bliss mill installations, terminal and auxiliary equipment.

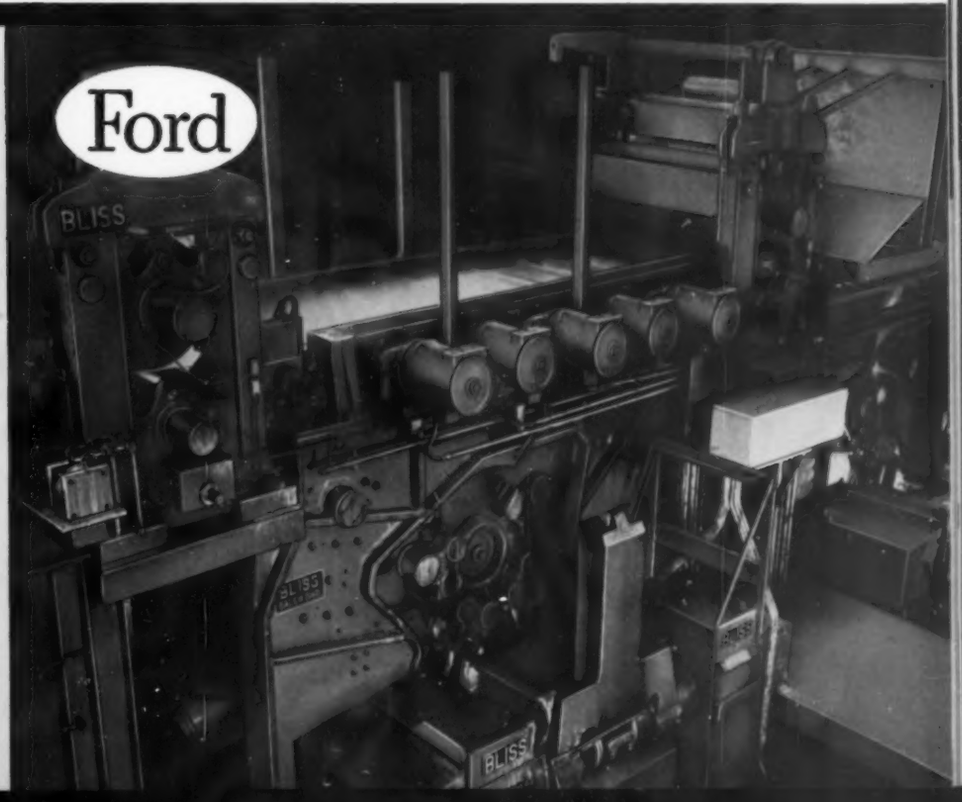
E. W. BLISS COMPANY, General Office: Canton, Ohio
ROLLING MILL DIVISION: SALEM, OHIO

BLISS
SINCE 1857

is more than a name...it's a guarantee

"Wind coils tight... and straight"

At River Rouge, this high-speed mandrel-type downcoiler by Bliss "rolls up" strip on an arbor with constant high-tension applied. Thus coils *are* tighter, more uniformly wound. Surfaces and edges are better protected, and better metallurgical characteristics are realized. After coiling, the mandrel collapses and facilitates coil stripping. Versatile, it handles a wide range of speeds, strip widths and gages. Bliss also designed and built a Four-High temper mill complete with heavy coil handling equipment for the Ford Motor Company.



IN THE STEEL INDUSTRY, TORRINGTON BEARINGS *are used on work rolls, back-up rolls and many auxiliary applications such as drives, pinion stands, coilers and ingot cars.*

Courtesy of U. S. Steel

TORRINGTON Steep-Angle Two-Row Tapered Roller Bearings

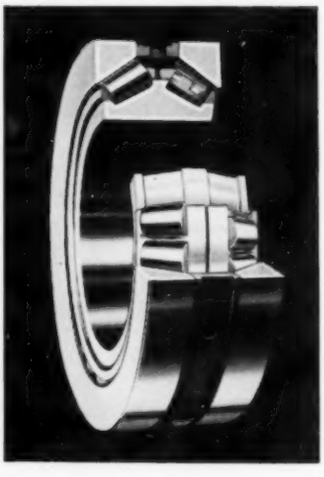
are built to handle heavy axial thrust loads

TORRINGTON BEARINGS are designed and manufactured to meet the high speed, heavy duty conditions of modern steel mill applications.

They are made from selected quality, electric furnace alloy steels, heat treated according to the most advanced metallurgical procedures.

TORRINGTON TAPERED ROLLER BEARINGS are available with one-piece, cast bronze cages or with pin-type construction. Many sizes of Back-up Thrust Bearings are available from stock for immediate shipment.

Specify TORRINGTON for your steel mill applications! They're rugged and dependable. They'll give you long, efficient, low maintenance service.



THE TORRINGTON COMPANY
South Bend 21, Ind. Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON TAPERED ROLLER BEARINGS

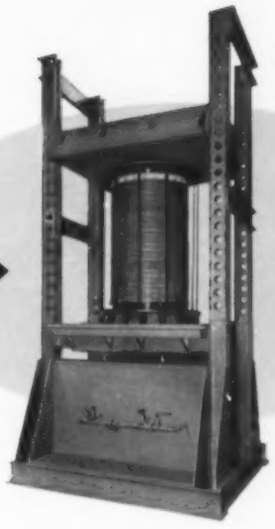
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

Over 15 years' experience in

"Putting on the Pressure"

is your proof that your

PENNSYLVANIA



Pressures up to 600,000 pounds can be applied to coils by this Pennsylvania hydraulic press.

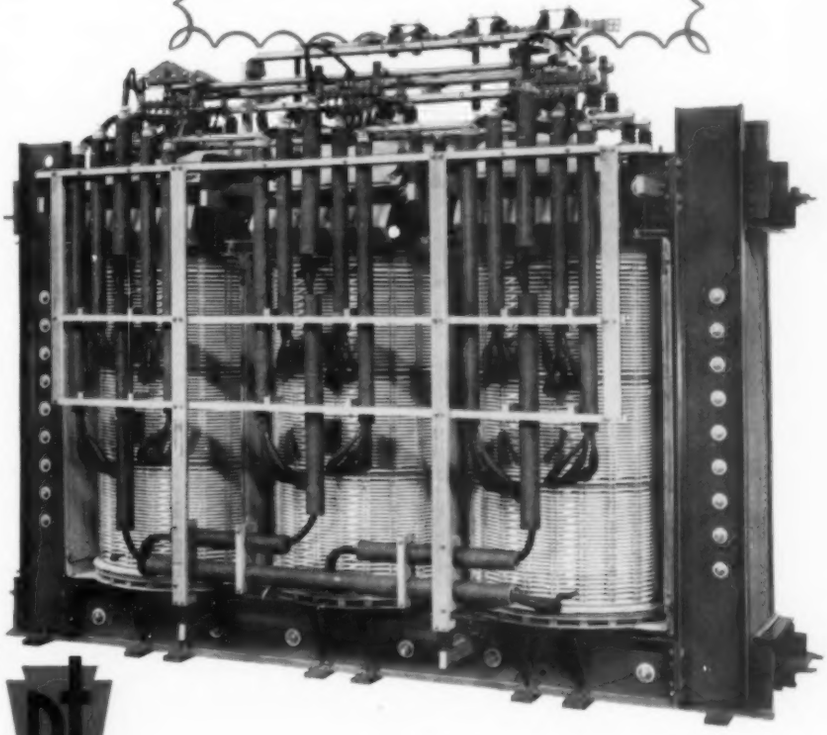
Power TRANSFORMER

will withstand short circuits

When a large power transformer is subjected to a short circuit, a force of several hundred thousand pounds may be imposed axially on its coils. Of course, these short circuit forces are taken into account in the design of each transformer. But at Pennsylvania, "proof on paper" is not enough. Positive action is taken to be absolutely certain that your transformer will withstand short circuits. Putting on the pressure is the added measure of safety engineered into every helical and pancake coil. Pennsylvania engineers calculate the total short circuit force that would be produced by a short circuit at the secondary terminals with the rated voltage maintained on the primary. Each coil is then compressed with this predetermined force. Finally, the coil is treated in such a manner that it will maintain its compressed size and shape when mounted on the core.

This idea, as well as this method of precompressing coils, was devised by Pennsylvania Transformer Company over 15 years ago. It has been a regular step in Pennsylvania's manufacturing process ever since then.

The fact that the transformer coils maintain their shapes under the prescribed pressure is your guarantee that the transformer will withstand short circuits.



Core and coil unit of 20,000 Kva, three phase transformer. Strong supports are provided at the top and bottom of the coils to keep the coils in their precompressed shapes. No movement can take place in these transformer coils, even under the most severe short circuit.

PENNSYLVANIA TRANSFORMER COMPANY • **BOX 330, CANONSBURG, PENNSYLVANIA**

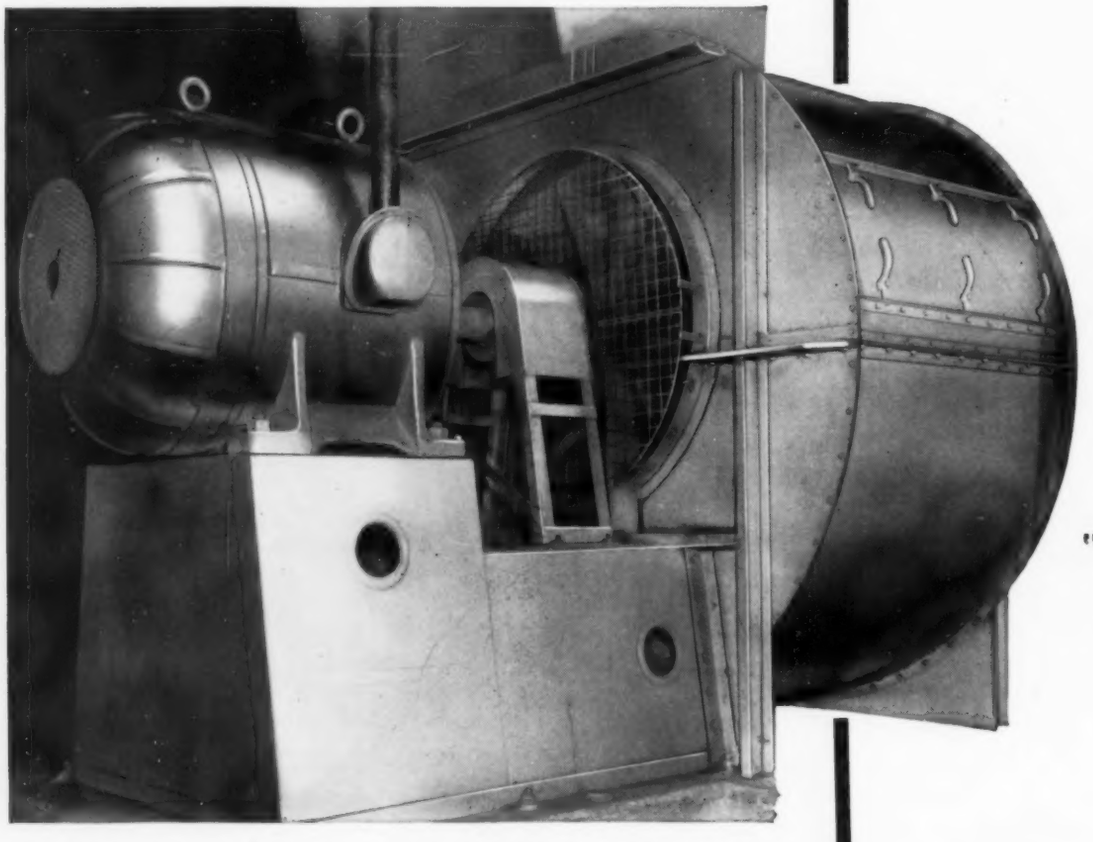
A McGraw Electric Company Division

PROTECTIVE C-O-O-L-I-N-G FOR YOUR MILL MOTORS

It takes tremendous volumes of air to keep mill motor temperatures in line! This cooling job calls for fans that can keep delivering under severe conditions of heat and pressure — "Buffalo" Mill Motor Fans.

These fans are "built up" to the job. Rotor blades are of heavy-gauge plate — stiff and strong. Housings are equally rigid and sturdy. Shafts are turned from solid alloy steel forgings. Rotors are dynamically and statically balanced, and have massive hubs. Bearings are oversize. It's all part of the famous "Q" Factor* that has made "Buffalo" a best fan buy for 78 years. Don't leave an important job like motor cooling to chance — specify "Buffalo."

*The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.



This "Buffalo" Fan cools motors continuously and dependably in a prominent mill. Write today for details on these fans built for the long run!

"BUFFALO" MILL MOTOR FANS

BUFFALO FORGE COMPANY

173 Mortimer Street — Buffalo, N. Y.

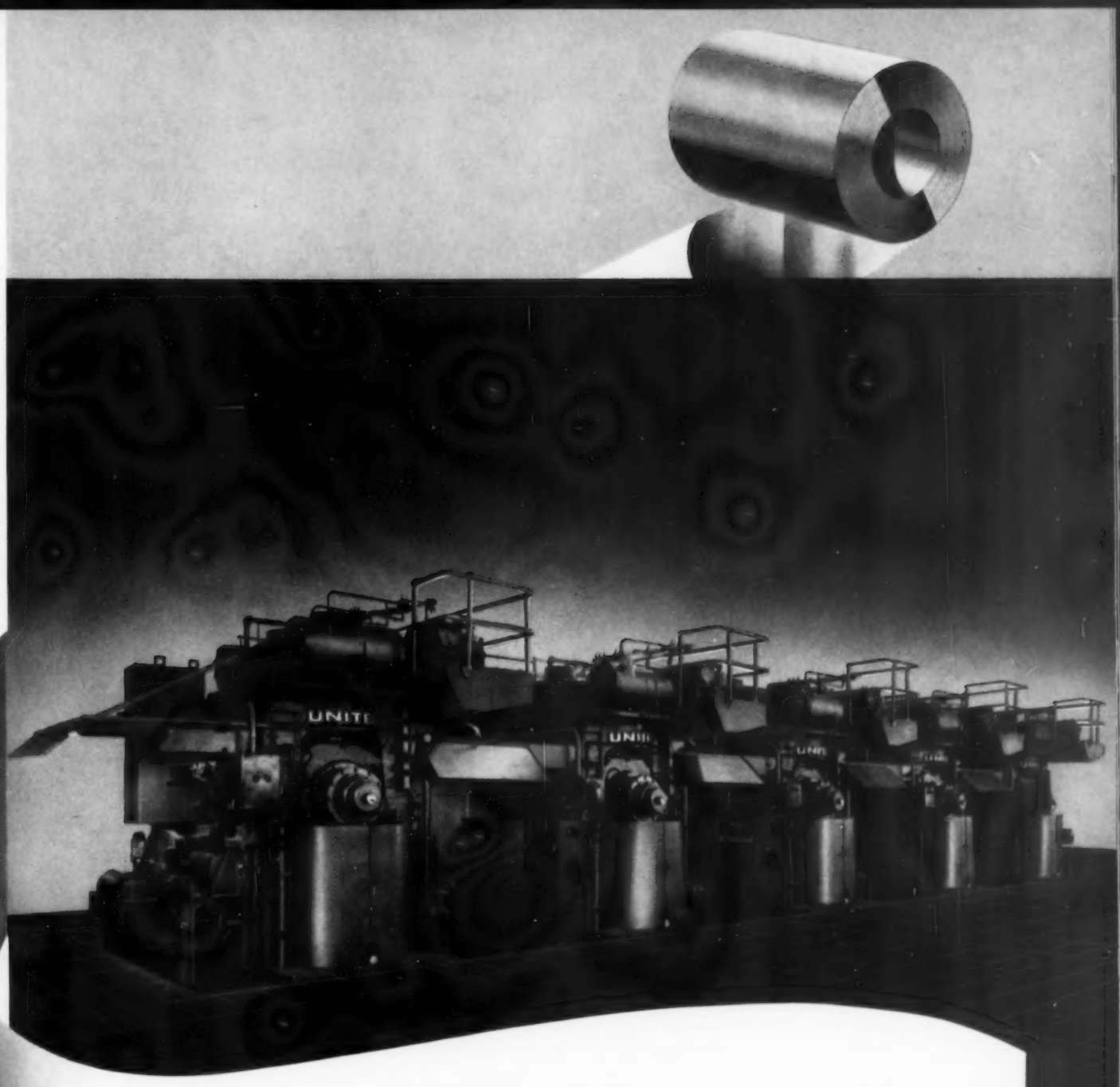
PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

Sales Representatives in all Principal Cities

"Buffalo"

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING
FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING



UNITED

5-stand Tandem
4-high Cold Mill

UNITED ENGINEERING AND FOUNDRY COMPANY

Pittsburgh, Pennsylvania

Plants at Pittsburgh • Vandergrift • Youngstown • Canton • Wilmington (Lobdell United Division)

Subsidiaries:

Adamson United Company, Akron, Ohio

Stedman Foundry and Machine Company, Inc., Aurora, Indiana

UE&FCO REG. T. M.

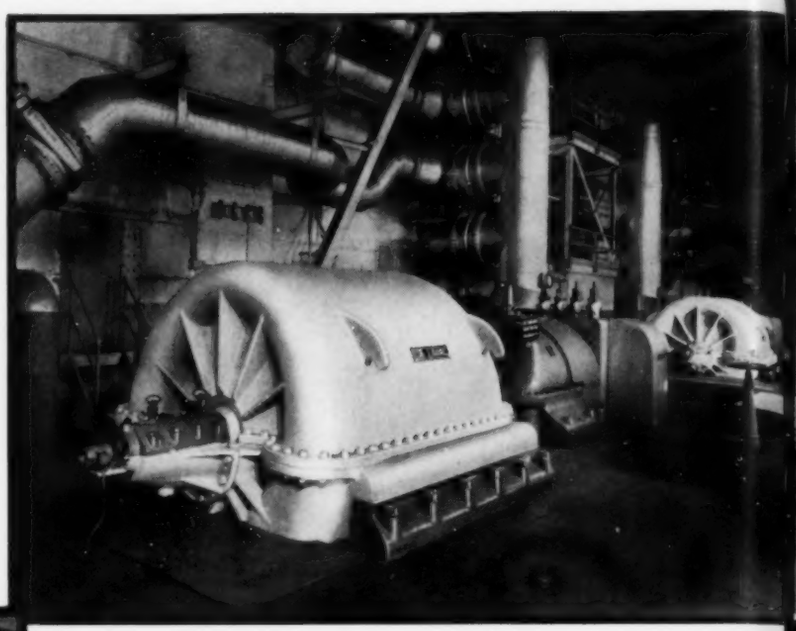
Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery. Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments.

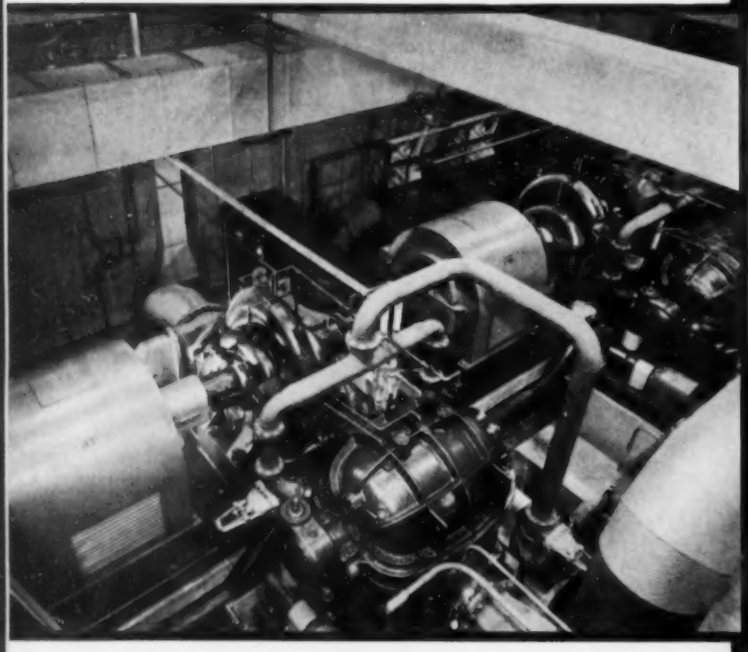
DE LAVAL
CENTRIFUGAL BLOWERS AND PUMPS

stay on the line for years at Jones & Laughlin

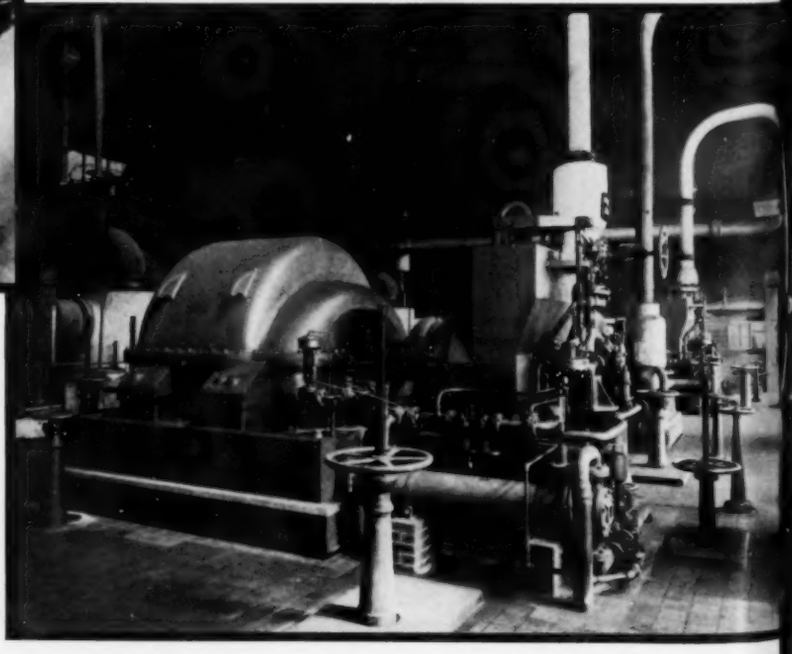
Jones & Laughlin reports: "*We have been using De Laval equipment for many years, and from our experience we have learned that De Laval blowers and pumps are inexpensive to maintain. Service is excellent. We can get spare parts quickly.*"

Three De Laval 22,000 gpm motor-driven pumps are on the job at Jones & Laughlin Steel Corporation in Pittsburgh, Pa. These units are used to pump river water to the open hearth and general mill. Installed in October 1951, these three pumps "have not had any downtime at all since their installation except for periodic inspections," Jones & Laughlin reports.





These two De Laval centrifugal blowers, each rated at 100,000 cfm, are in use 24 hours per day, seven days per week except for a yearly inspection period. Since installation, there has been only 24 hours downtime in one of these blowers with a maintenance cost of about $400. "That's very little for this type of equipment," says the Jones & Laughlin blower room foreman.



This is one of three De Laval gas exhausters, operating at 48,000 cfm around the clock. Two of these units can handle maximum capacity; the third is used as a spare. Jones & Laughlin says, "Without good gas exhausters you would have to 'bee hive' (open the top and permit the gas to go free), thus losing our by-product."

Send for Bulletin 0504

DE LAVAL *Pumps and Blowers*

DE LAVAL STEAM TURBINE COMPANY
870 Nottingham Way, Trenton 2, New Jersey

DL 297

Alliance manipulators

Illustrated here are four standard types

20-Ton Floor Type Straight Line Manipulator

20-Ton Floor Type Manipulator arranged for slewing 360°

Axel Forging Manipulator Bridge Floor Type—slews 360°

20-Ton Crane Type Manipulator—slews 360°

Alliance Builds All Types of Forging Manipulators

All Alliance manipulators are equipped with power grip revolving tongs, main hoist and leveling hoist.

Longitudinal travel for trolley type manipulators.

Longitudinal and transverse travel for bridge type manipulators.

Consult Alliance engineers regarding your forging problems. For more than 50 years The Alliance Machine Company has collaborated with engineers in the design of material handling equipment for all steel mill products.

World's Largest Builder of the World's Largest Cranes

THE Alliance MACHINE COMPANY

Founded 1901 *Main Office, Alliance, Ohio*

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION • COKE PUSHERS

All finishing stands on new Japanese strip mill are TIMKEN® bearing equipped

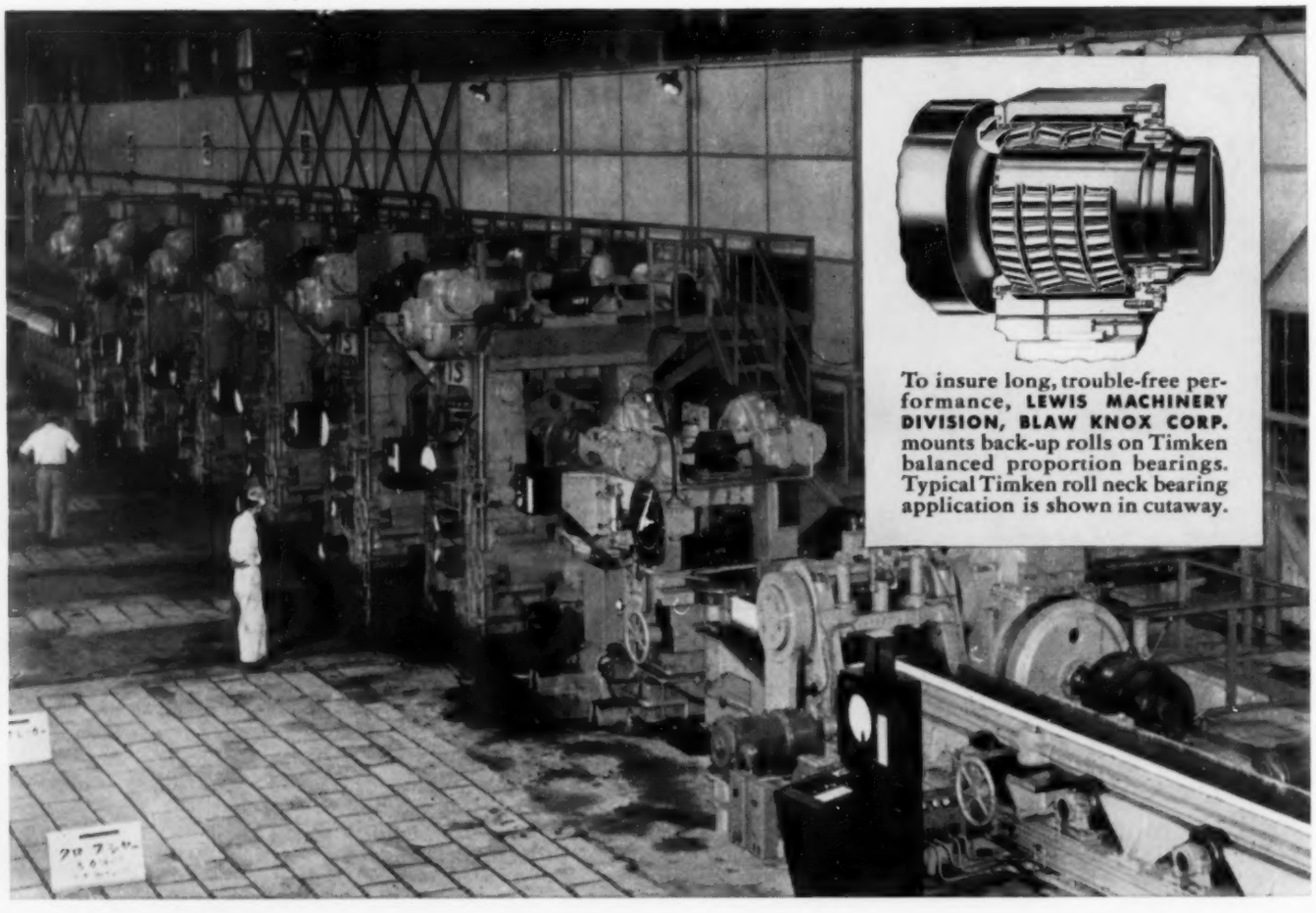
THIS Lewis 4-hi hot finishing strip mill, recently put in operation in Japan, gets maximum tonnage at minimum bearing costs with Timken® tapered roller bearings in all six finishing stands. That's because Timken bearings help keep the mill on the job, day after day, with less time-out for maintenance and repairs.

All back-up rolls are mounted on Timken balanced proportion bearings. They provide greater mill rigidity because they permit larger diameter roll necks than standard roller bearings. Load ratings are increased up to 40%, roll neck strength increased 50 to 60%.

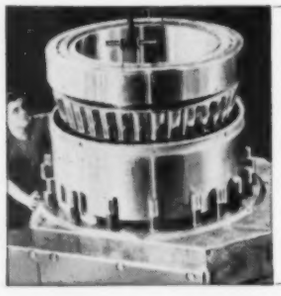
Timken bearings eliminate complicated lubrication systems, permit the use of simple and economical grease lubrication. Rolls can be changed quickly and easily. No special thrust bearings are needed because Timken bearings take radial and thrust loads in any combination. Since Timken bearings practically eliminate friction, higher rolling mill speeds are possible.

Years of research and development by the Timken Company have resulted in many improvements in roll neck bearing design and performance. For full information, consult our roll neck bearing specialists. Write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



To insure long, trouble-free performance, **LEWIS MACHINERY DIVISION, BLAW KNOX CORP.** mounts back-up rolls on Timken balanced proportion bearings. Typical Timken roll neck bearing application is shown in cutaway.



ROLL NECK BEARING ENGINEERING SERVICE

Our field and service engineers have had years of experience with problems of roll neck bearing design and operation. They'll help you select bearings and design mountings.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis Timken steels.

TIMKEN

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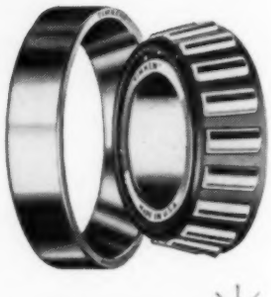
TAPERED ROLLER BEARINGS



NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↕ AND THRUST →← LOADS OR ANY COMBINATION

Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period October 5, 1954 through October 26, 1954 . . . .

REDUCTION OF SULPHUR CONTENT WITH CALCIUM CARBIDE

▲IT has been known for many years that calcium carbide is an excellent desulphurizing agent for iron and steel, since it combines readily with the sulphur present. Nevertheless, it has not been utilized because of the difficulty arising from the fact that calcium carbide does not melt at the temperatures of molten iron and steel. The reaction must be effected between a solid reagent and the liquid molten metal. It depends, therefore, upon surface contact between the solid calcium carbide and the molten metal.

It has been proposed to blow the calcium carbide, in a finely divided condition and suspended in a stream of gas, into the molten metal. Such a suspension requires the use of a large amount of gas in proportion to the carbide supplied. The suspended carbide is principally carried in the bubbles of gas which rise through the molten metal and never comes into contact with it. Most of the carbide used is thus ineffective, and the low efficiency of the procedure makes it impractical.

U.S. 2,692,196, issued October 19, 1954 to Philip M. Hulme, and assigned to Air Reduction Co., Inc., provides an efficient and practical method and apparatus for injecting calcium carbide into a molten ferrous metal bath in order to cause a highly efficient reaction.

In the present invention, gas is used not as a carrier for the carbide, but to prevent the molten metal from rising in the submerged passage through which the carbide is delivered beneath the surface of the molten metal. The carbide falls by gravity through the passage and is disseminated through the molten metal as it rises. While the gas will escape and rise as bubbles through the molten metal, the gas does not carry any substantial portion of the carbide in suspension because of the relatively low ratio of gas to solid and thus does not remove it from effective contact with the metal before the reaction can be accomplished.

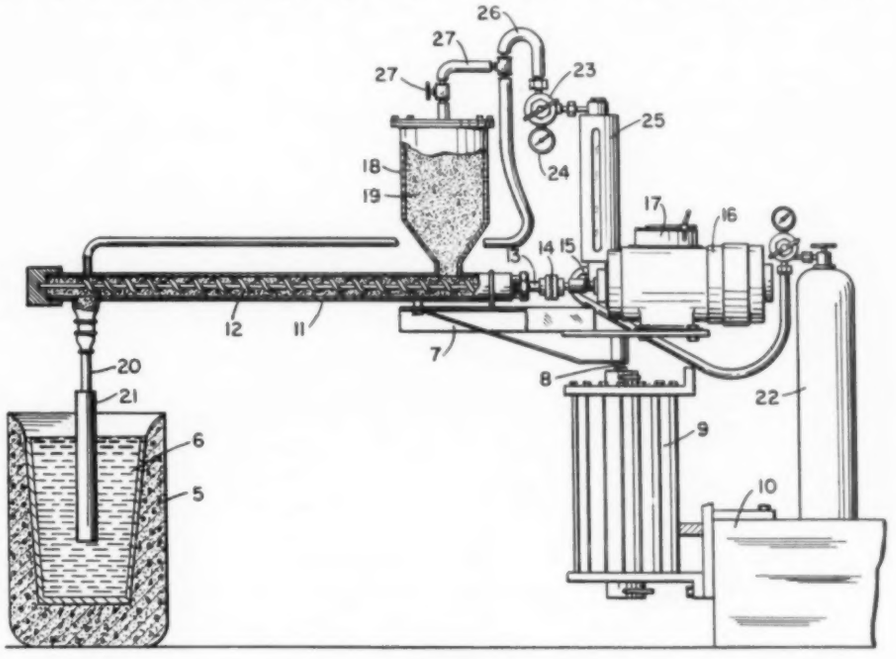


Figure 1

It has been found that when the calcium carbide and the gas are employed in the proportions of about two cu ft of gas per lb of carbide, it is

possible to effect a better than 90 per cent extraction of the sulphur from the molten metal with 35 per cent efficiency of the carbide reaction. This is in marked contrast with the procedure previously employed, which utilizes approximately 100 cu ft of the gaseous carrier per lb of calcium carbide, with approximately 10 per cent extraction of the sulphur and an efficiency of one per cent in the carbide reaction.

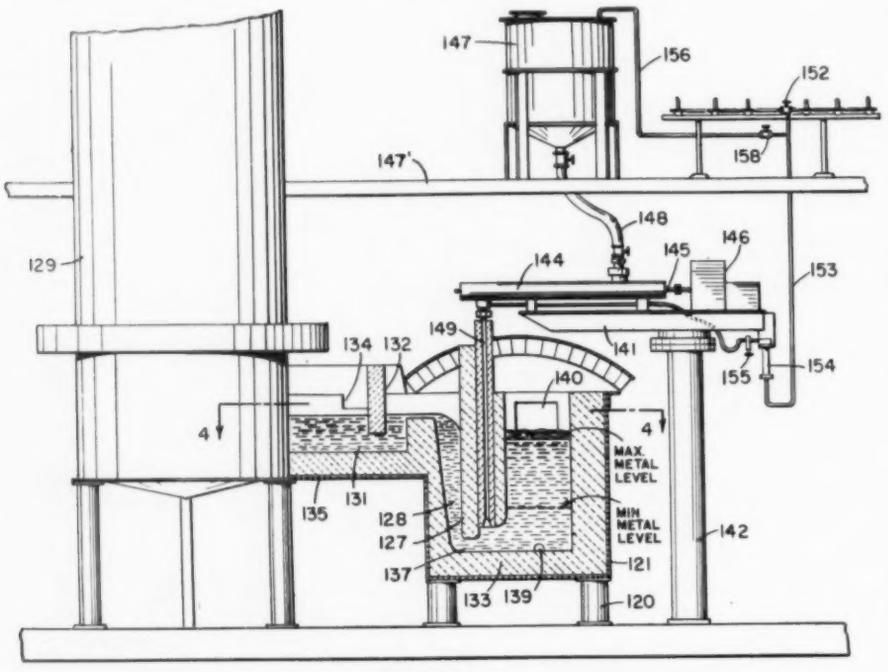


Figure 2

A number of different ways of carrying out the basic idea are described in the patent, several of which will be presented here.

Figure 1 shows a method of carrying out the process in a batch operation. A receptacle 5 carries a charge 6 of molten metal for treatment. A frame 7 is mounted on the plunger 8 of a hydraulic cylinder 9. The frame 7 carries a tube 11 in which a worm 12 is driven by a motor 16, the shaft 15 being driven through variable speed mechanism 17. A hopper 18 contains a charge of carbide 19 in finely divided form. The carbide descends from the hopper into the tube 11 and is advanced by the worm 12 to the end of the tube 11, where it falls by gravity into a tube 20 which extends into a refractory member 21 which extends well into the molten metal.

In order to prevent the molten metal from rising in the member 21, a gas is provided from a cylinder 22, which is connected through a flowmeter 25 to a pressure-reducing valve 23. The gas is delivered as required through a pipe 26. A by-pass pipe 27 connects the pipe 26 to the closed cover 28 of the hopper 18 so that the gas pressure is equalized in the chamber above the carbide. The pressure of the gas supplied is maintained at a point which will overcome the static head of the molten metal in the member 21, thus preventing the molten metal from rising in the passage through the member 21, leaving the carbide free to fall by gravity to the lower end of the member 21. Various gases may be used, provided the selected gas is dry and oxygen-free, e.g. nitrogen, carbon dioxide, propane, or natural gas.

Exceptionally low levels of sulphur content in molten ferrous metal may be attained with the apparatus illustrated in Figure 1 in a comparatively short time. For instance, in open hearth operations, depending on cupola iron for hot metal, the cupola iron runs anywhere from 0.17 to 0.20 per cent sulphur, and when a final specification of 0.025 per cent is required at least two hours of extra refining is needed in the open hearth. Also, several times the normal lime and ferromanganese additions must be made to meet the specification. By the present process, the cupola iron is originally reduced to less than 0.010 per cent in sulphur, so no time is required in the open hearth for desulphurizing, less lime and ferromanganese are required, and the total slag volume is one-third or one-half that in the former practice.

Figure 2 shows the application of the process to the continuous treatment of a molten ferrous metal which is supplied from a melting furnace or cupola 129 which delivers the metal continuously at a predetermined rate through a tap hole. The molten metal is delivered into a slag skimmer 131, having a baffle 132 to eliminate the slag through notch 134, and then through passage 128 of the forehearth 133, having side wall 127 with an opening 137 at the bottom. A slagging bay or opening 140 through the wall of the forehearth permits withdrawal of the slag and reaction products as required. Metal is tapped intermittently from the forehearth by removing a clay bot in tap hole 139, thus allowing the metal to flow through the tap hole 139 and a tapping spout.

The carbide feed mechanism is supported on a frame 141 carried by a column 142 resting on the floor. The frame 141 supports a tube 144 enclosing a worm which is driven by a shaft 145 connected to a variable speed motor 146. Calcium carbide is maintained in a hopper 147 mounted on the charging floor or support 147', and the carbide is delivered through a flexible tube 148 to the tube 144. It is delivered by the worm at a selected rate of feed to an injection pipe 149 surrounded by plastic refractory material. The pipe extends through the side wall of the forehearth and terminates at least three in. from the floor of the forehearth, and not less than six in. below the minimum surface level of the metal.

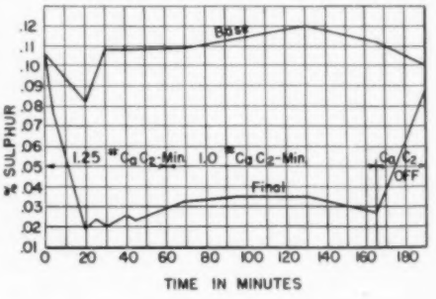
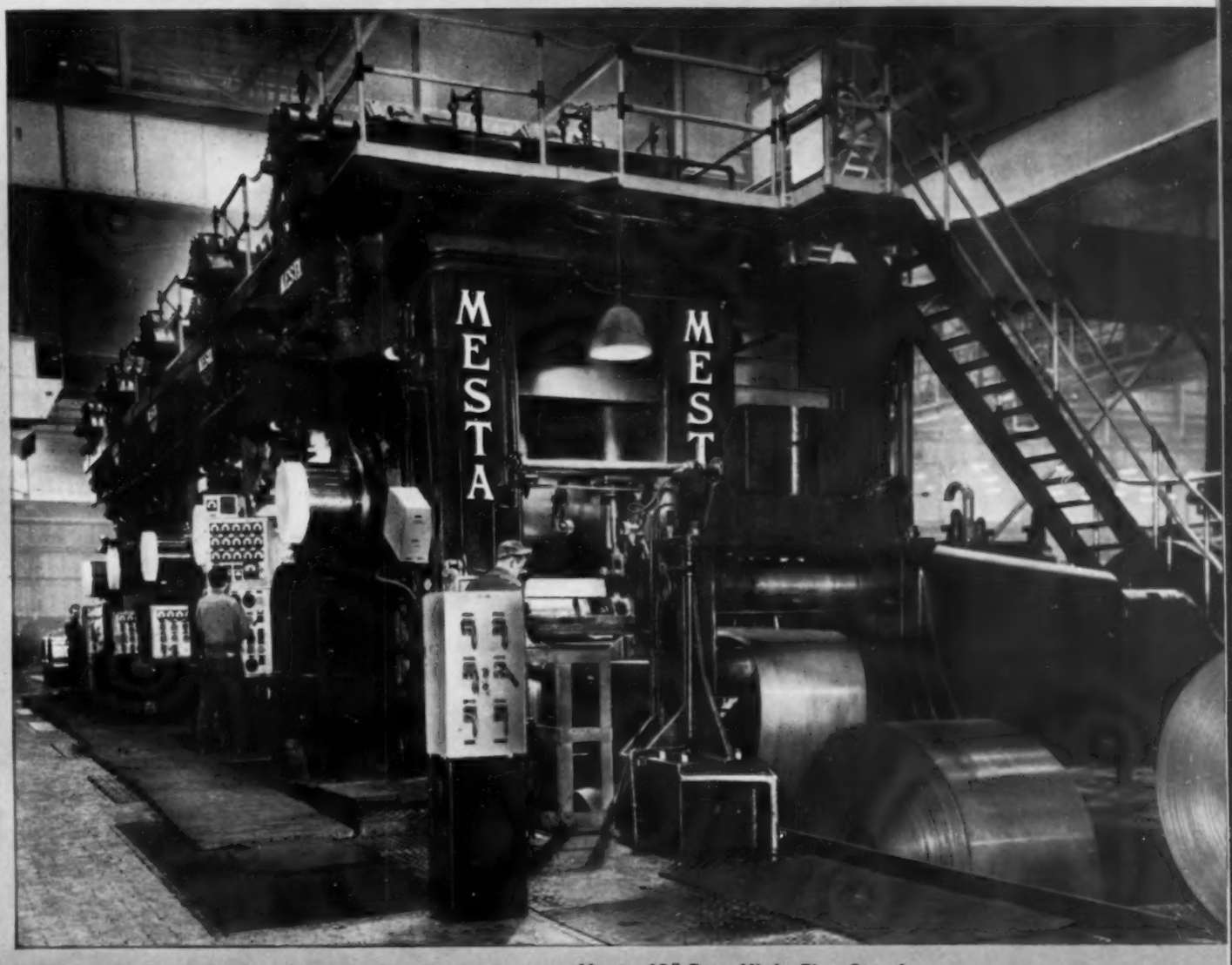


Figure 3

A number of cylinders (not shown), affording a supply of gas under pressure, are connected through pressure-reducing valves 152 to a pipe 153 which extends through a flow meter 154 and needle valve 155 to the outer end of tube 144, thus supplying gas to the upper end of pipe 149. A by-pass pipe 156 with a valve 158 delivers gas



Mesta 48" Four-High, Five Stand
High-Speed Tandem Cold Mill

Designed and Built by MESTA

The World's *HIGHEST SPEED* Cold Mill
FOR FAIRLESS WORKS, U. S. STEEL CORPORATION

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY, PITTSBURGH, PENNSYLVANIA

to the top of hopper 147 to maintain a balanced pressure on the carbide in the hopper. The patent describes this apparatus in considerable detail, particularly the injection pipe.

With apparatus of the continuous type, results such as shown in Figure 3 may be obtained.

The process is applicable to all ferrous metals, including acid or basic cupola or electric furnace iron; acid or basic electric furnace steel; acid or basic open hearth furnace steel; acid or basic bessemer converter and reverberatory or air furnace iron; and blast furnace iron. It can also be used for making upgraded cast iron and nodular cast iron.

CONTINUOUS CASTING OF METALS

U.S. 2,692,410, issued October 26, 1954 to Richard Chadwick and John F. Hobbs, assigned to Imperial Chemical Industries Ltd. (England), describes a method of continuous casting of ingots.

In one method of continuous casting, molten metal is poured into a short open mold and the emerging cast product is subjected to direct cooling by means of a water spray. This has many advantages, such as the production of fine grain and reduction of segregation, but the disadvantage that internal stresses are set up due to the large temperature drop from the interior to the exterior of the cast product, which are often sufficiently great to cause central cracking in cylindrical billets of certain alloys.

In the present invention, this difficulty is avoided, since the direct chill is interrupted at one or more points around the periphery. This can be done by providing a deflector plate attached to the mold to divert the coolant at the selected positions. When the cooling is carried out by means of separate spray rings below the mold, the interruption may be obtained by the use of an incomplete ring of jets. Points of weakness are introduced at the hotter places in the billet, which facilitate release of stress by allowing a slight distortion of the circular cross-section.

It is claimed that this method makes it possible to produce casting at speeds up to one in. per min higher than those obtainable without the interrupted chill.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,690,600	10/ 5/54	Device for introducing the lubricant into the mold for the continuous casting of iron and steel	Bruno Tarmann and Rudolf Obauer
2,691,515	10/12/54	Forge furnace control	Surface Combustion Corp.
2,691,576	10/12/54	Wear-resistant cast iron for cylinder liners	General Motors Corp.
2,691,819	10/19/54	Coiling silicon steel strip	Wheeling Steel Corp.
2,691,906	10/19/54	Sizing pipe ends	Jones & Laughlin Steel Corp.
2,691,907	10/19/54	Forging press with separable rolls	The National Machinery Co.
2,692,003	10/19/54	Apparatus for forming metal strips of curved cross-sections	Bethlehem Steel Co.
2,692,050	10/19/54	Partial reduction of iron ore	Standard Oil Development Co.
2,692,229	10/19/54	Disposal of waste pickle liquor	A. O. Smith Corp.
2,692,458	10/26/54	Abrasive-blast apparatus for cleaning cylindrical workpieces	United States Steel Corp.
2,692,773	10/26/54	Automatic self-centering roll	United States Steel Corp.

ACID PICKLING COMPOSITIONS

New pickling compositions are disclosed by Allan E. Chester and Joseph T. Irwin in U.S. 2,692,187-8, issued October 19, 1954 and assigned to Poor & Co. (Chicago, Ill.) It is claimed that pickling is accelerated, pickling tank life is increased and better surface conditions for adherence of electrodeposited metals is obtained by adding sodium thiosulfate and chromium gluconate. Additional improvements are also claimed to occur when sodium thiosulfate and sodium thiocyanate are added to the pickling bath.

DISPOSAL OF WASTE PICKLE LIQUOR

U.S. 2,692,229, issued October 19, 1954 to Lorenz William Heise and Milton Johnson, assigned to A. O. Smith Corp., describes a process for treating waste pickle liquor before disposing of it to the sewer.

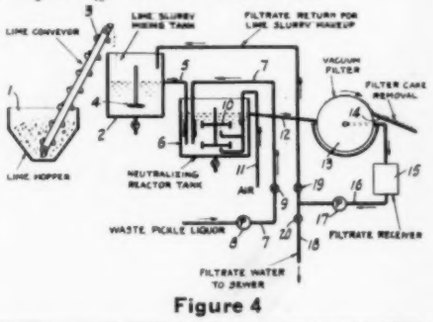


Figure 4

As shown in Figure 4, the waste pickle liquor is first neutralized by means of a lime slurry, which also has the effect of precipitating iron salts. Air is then blown into the neutralizing reactor tank, while the precipitated salts are suspended by an agitator. This oxidizes from two to five per cent of the ferrous constituents in the precipitate to the ferric state, thereby greatly increasing the filterability of the solution. After filtration, the filtrate is discarded to the sewer.

WANTED!

There is a constant demand for copies of "The Modern Strip Mill," published by the Association of Iron and Steel Engineers.

If your copy is not in use please get in touch with us.

ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

Here ends one of America's worries about steel!

THESE "iron marbles" are opening a vast new source of high grade raw material for the iron and steel industry.

Steel men have worried for years about the dwindling supply of easily-accessible 52% iron ore in the Mesabi range and the rapid depletion caused by war-time and postwar production. But something important has been done about it.

McKee engineers collaborated on a method for producing heat-hardened pellets from low-grade taconite, the iron-bearing rock of which the Mesabi range is largely composed. The new product, containing 60 to 65% iron, is superior in almost every way to the highest-grade ore ever mined in the area.

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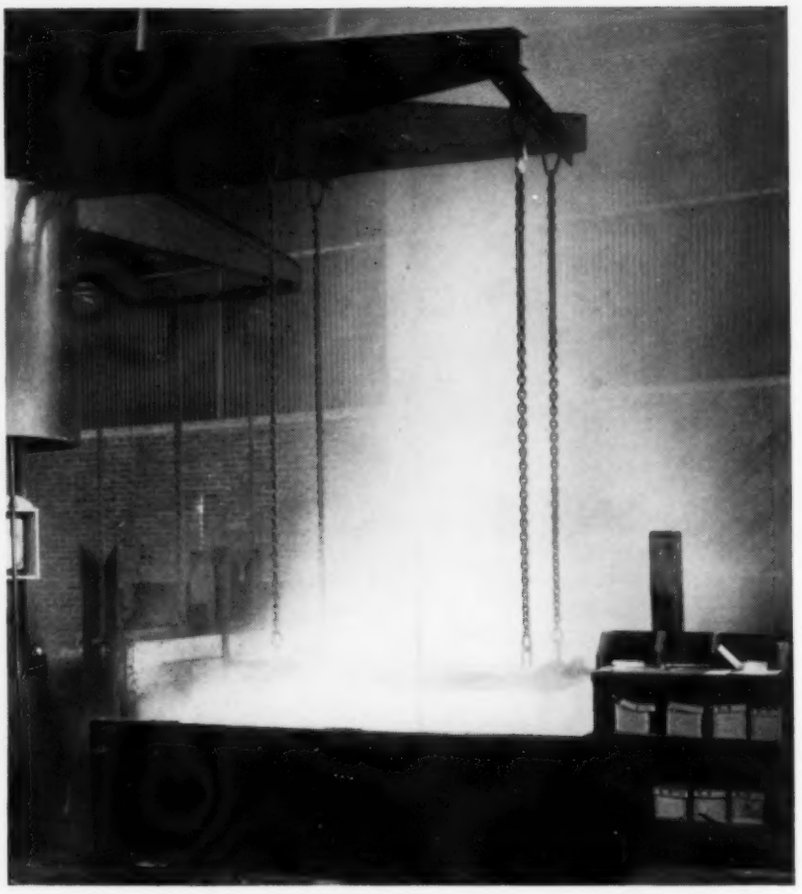
FIRST AID TO STEEL IN A PICKLE—



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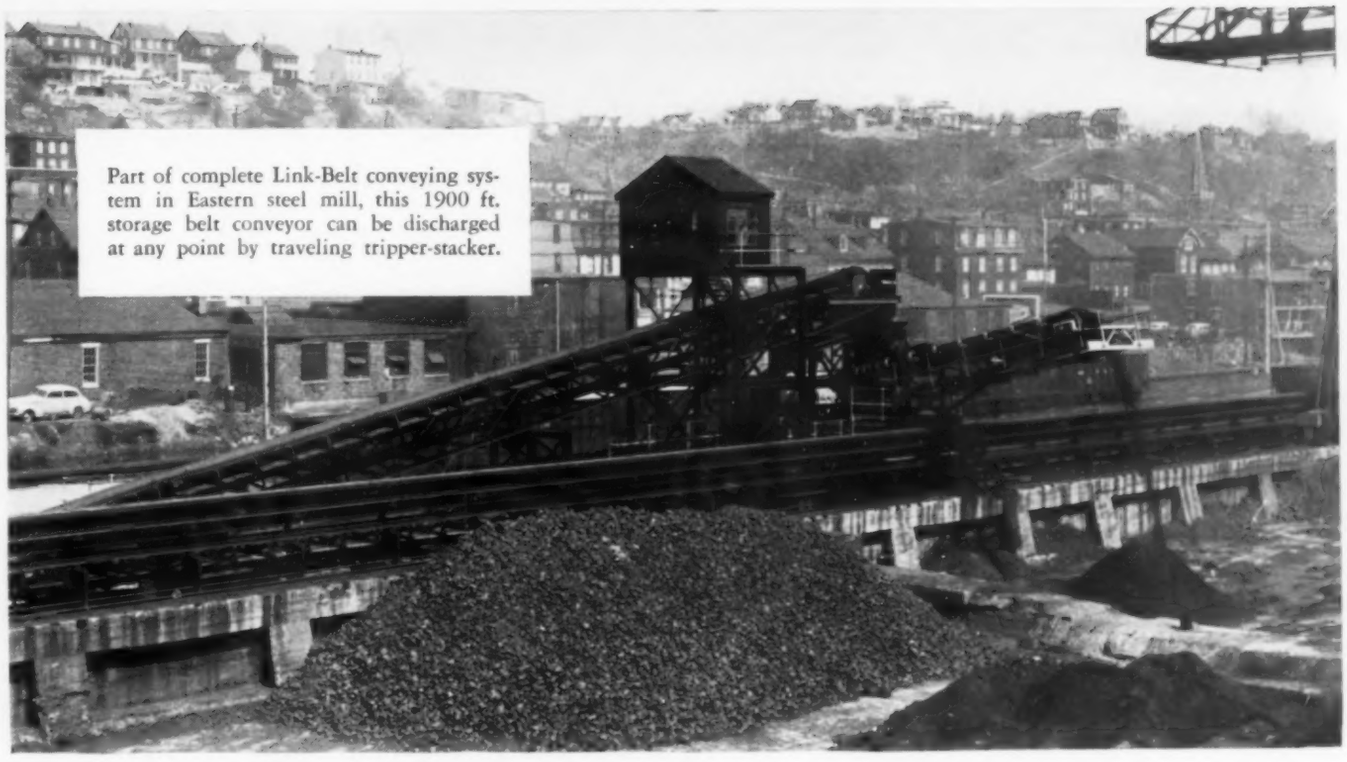
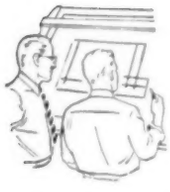


Part of complete Link-Belt conveying system in Eastern steel mill, this 1900 ft. storage belt conveyor can be discharged at any point by traveling tripper-stacker.

SURE ROAD TO LOWER HANDLING COSTS

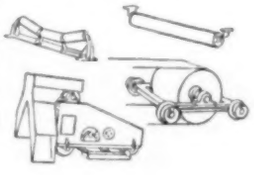
... carry the load via Link-Belt belt conveyors

LINK-BELT offers you the "total engineering" so necessary for top efficiency

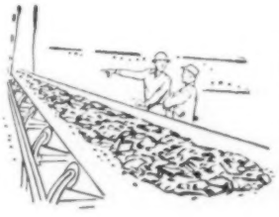


DESIGNED FOR OVERALL EFFICIENCY—Because of its unrivaled experience, Link-Belt can do a better job of gathering and analyzing all data. Proposals reflect this understanding of the most practical way to fit individual conveyors into your overall system requirements for best results.

BUILT FOR LONG-LIFE PERFORMANCE—Link-Belt manufactures all components and related feeders and conveyors. You are assured of the right equipment because of this breadth of line. And Link-Belt will supply the highest grade belts engineered to the specific job.



DELIVERS FULL RATED CAPACITY—Link-Belt follows through on every detail of the job, including electrical controls and even wiring and foundations. What's more, Link-Belt will furnish experienced erection superintendents, staffs and skilled crews at the customer's request.



ASSURES SATISFACTORY PERFORMANCE—When you rely on Link-Belt as a single source for your complete system, we accept responsibility for placing it in full operating readiness. We will also supervise modernization of existing systems. For all the facts call your nearby Link-Belt sales representative.

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13.446-C

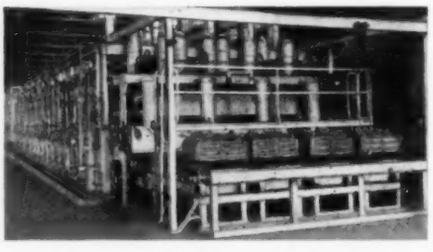
How to Select the Most Economical Insulating Firebrick

The advantages of lightweight insulating firebrick over ordinary "heavyweight" firebrick are generally known to furnace operators and furnace builders. But many buyers have wondered just what advantages there might be in one brand of insulating firebrick as against another. The answer to this question could very well mean savings in fuel costs, increased furnace output, longer life . . . or all three.

One furnace builder ran tests on their small electric kilns where heat input could be measured with great accuracy. Here's what they found: B&W IFB required 25% less heat than any other brand of insulating firebrick they tried.

The reason? B&W IFB are lighter in weight than any other insulating firebrick — they contain more tiny, insulating air cells. Heavier, denser insulating firebrick linings waste fuel two ways: They soak up and store more heat which is lost when the furnace is cooled; and they conduct more heat through the walls.

How about long life? One of the

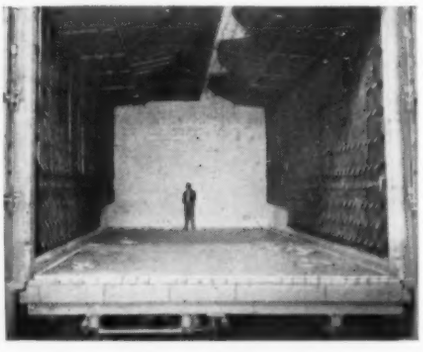


toughest tests of firebrick is in the lining of a carbon monoxide furnace. Some brands last only a few weeks, then disintegrate, due to iron oxide impurities in the brick which react with the gas.

But B&W Insulating Firebrick contain little iron oxide, and they're processed at high temperatures so that any traces of iron oxide form stable compounds. So instead of deteriorating they stay on the job year after year —in many cases over 10 years.

Another factor, important to many furnace operators, is accurate temperature control. Here again B&W IFB have an advantage over other insulating firebrick. First, because B&W IFB are lighter in weight they store and conduct less heat—and they respond more quickly to changes in heat input.

A typical example is the giant stress-relieving furnace shown below—sixty feet by twenty-two feet by seventeen feet high. The B&W lining plays a vital part in holding the desired temperature within 5 degrees accuracy!



Next time you buy or specify insulating firebrick, remember that the lightest weight brick of all—B&W—has the highest insulation value, the longest life and the greatest furnace heat controllability.

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Refractories Division
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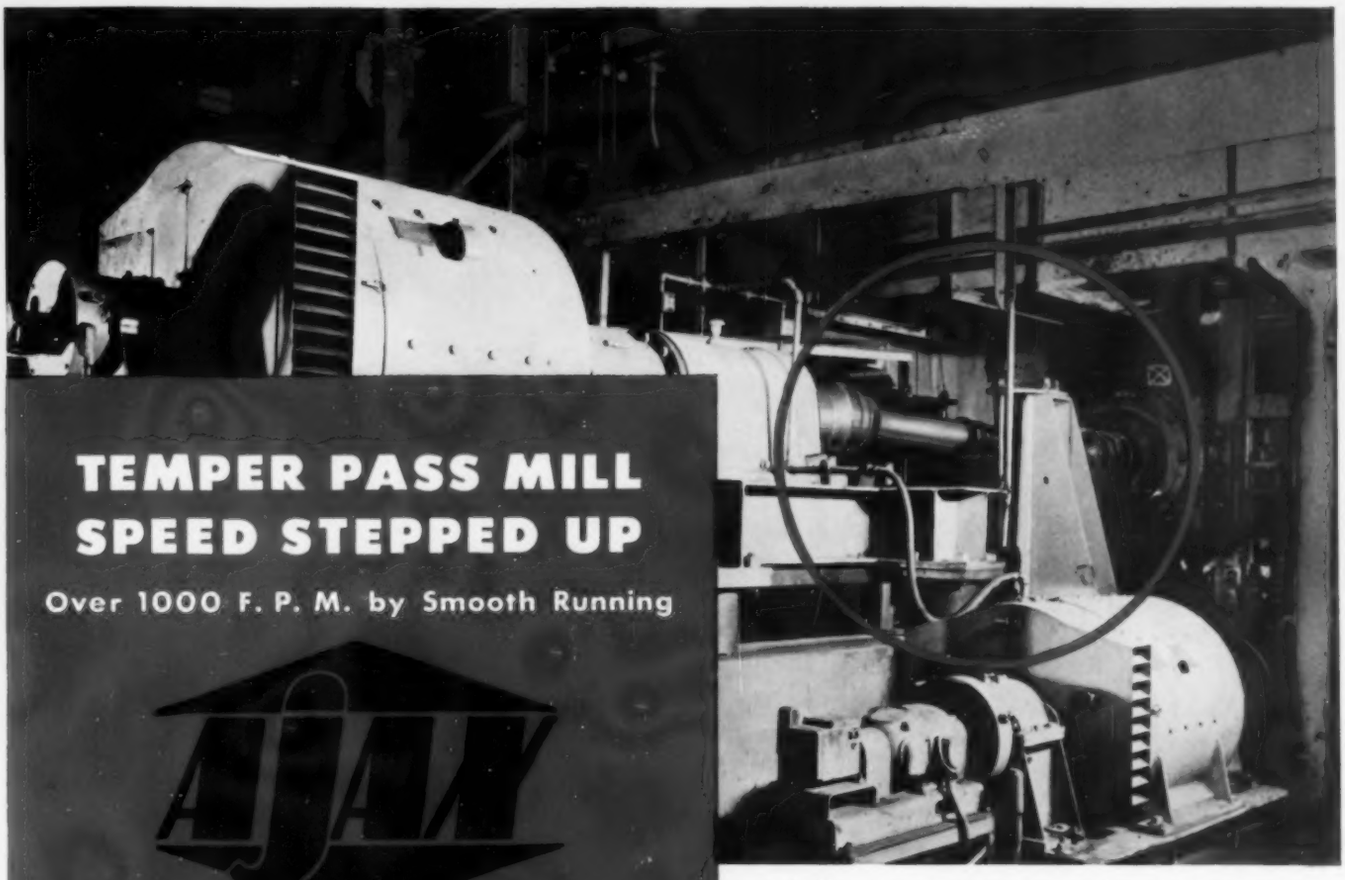


TEMPER PASS MILL SPEED STEPPED UP

Over 1000 F. P. M. by Smooth Running

AJAX

DIHEDRAL SPINDLE SHAFT COUPLINGS

Spindle Drive side of 2-stand tandem tin temper pass mill equipped with Ajax Dihedral Spindle Shaft Couplings designed to transmit 400 H. P. at 400 R. P. M.

THIS photograph shows the first stand of a two-stand tandem tin temper pass mill designed and built by E. W. Bliss Co., for Jones & Laughlin Steel Corporation . . . Aliquippa Works. This mill was designed to be the fastest temper pass mill in the world with operating speeds over a mile a minute. Conventional couplings were replaced by Ajax Dihedral Spindle Shaft Couplings and speed was stepped up over 1000 F. P. M.

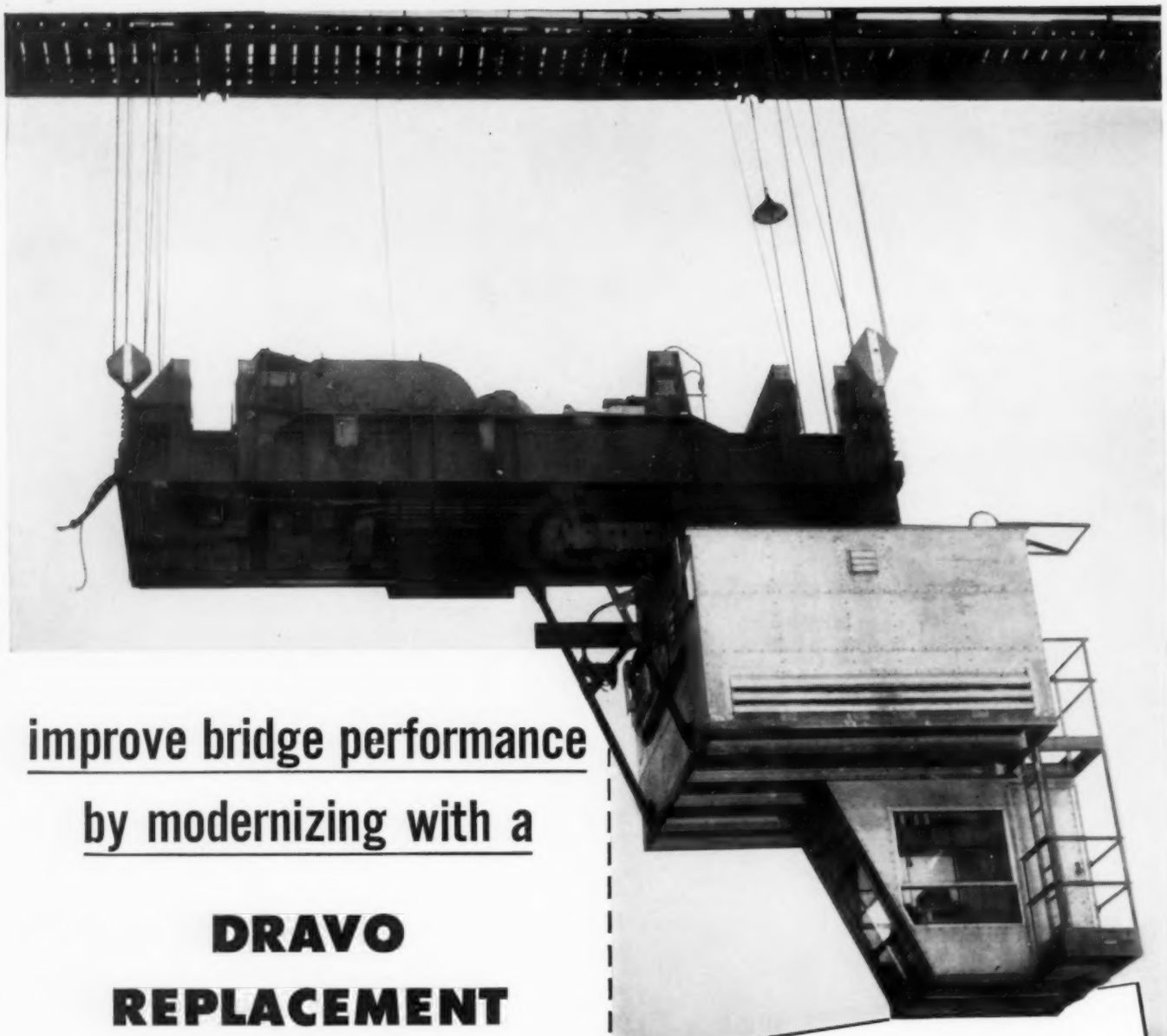
This is another dramatic example of how Ajax Dihedral Spindle Shaft Couplings are making all other types of conventional couplings obsolete. Their uniform peripheral speed, ability to handle maximum misalignment with tooth clearance limited to lubrication film requirements, elimination of vibration and minimum maintenance are reasons why mill operators are welcoming Ajax Dihedral Couplings with open arms.

Cut away view of Ajax Dihedral Coupling showing arrangement of teeth.

Write for complete data.

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, N. Y.



improve bridge performance by modernizing with a

DRAVO REPLACEMENT MAN TROLLEY

Granite City Steel Company increased their ore bridge capacity, to meet higher production schedules, by installing a Dravo Replacement Man Trolley.

Each part of the trolley is designed to conserve weight and meet specific bridge loading conditions with complete safety. This design improves performance by permitting:

1. **the use of a larger bucket**
2. **a faster operating cycle**
3. **an increase in volume of material handled**

It takes less than 24 hours to install a Dravo Replacement Man Trolley. Write for complete information.

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mated for a better life!

matched pairs of LEWIS ROLLS mean minimum grinding, greater productivity, lower cost of tonnage rolled

Remember, the tonnage you get from a pair of rolls is no better than what the roll of minimum diameter will deliver.

LEWIS realizes this and is doing something about it. Pairs of rolls from each heat are matched for diameter. A label is pasted on the end of the wabbler of each roll of each matched pair as it leaves the foundry, giving the roll number of its mate. Thus, the matched pairs can be quickly identified.

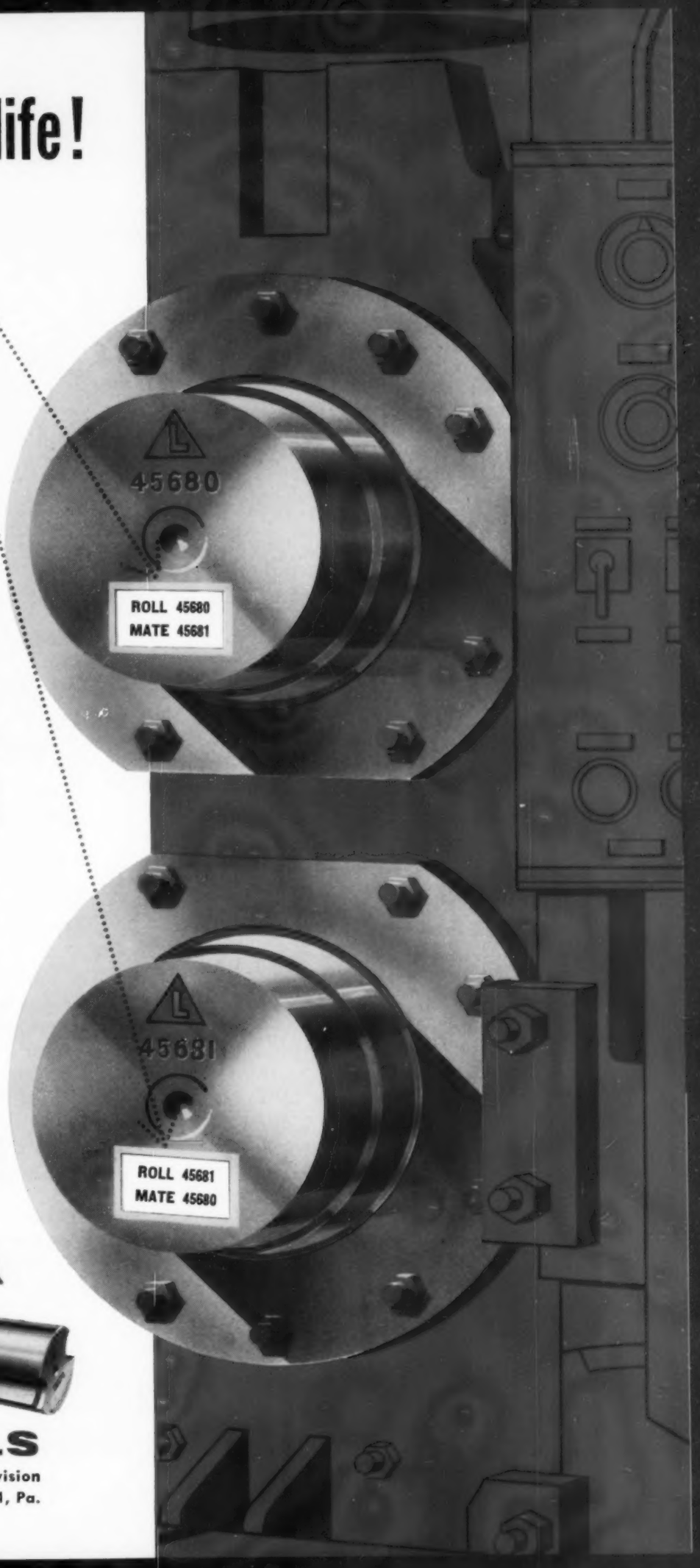
This LEWIS service helps the mill operator use rolls of the same diameter in a particular mill, with minimum grinding, and greater tonnage of quality products.

That's just another reason why you should always specify and use *quality* LEWIS ROLLS. They cost you less in the long run.

OVER 95 YEARS OF ROLL MAKING—

Superior "X" Rolls • Ajax Duplex Rolls • Lewis "X" and "XA" Rolls • Special Process Rolls • Climax and Ajax Rolls • Plain Chilled Rolls • Special Tube Mill Rolls • Atlas, Atlas "B" and Atlas "X" Rolls • Molybdenum Chilled Iron Rolls

Matched Rolls Mean Greater Tonnage



BLAW-KNOX

LEWIS ROLLS

BLAW-KNOX COMPANY • Rolls Division
Lewis Rolls Department • Pittsburgh 1, Pa.

FOR DEPENDABILITY, GRANITE CITY STEEL SPECIFIES OKOLITE-OKOPRENE CABLES

View of the new blooming mill at the Granite City Steel Co. plant in Granite City, Ill., from finished slab end. The entire mill, from the 5,000 hp motors for the two rolls to the control circuits, is wired with Okolite-Okoprene.

Simplicity of termination is one important reason for the trend to rubber-insulated high voltage cables. These are 12 kv rated Okolite insulated cables at the rear of the 6.9 kv motor switchgear.

Sverdrup and Parcel, Consulting Engineers
J. Livingston and Company, Electrical Contractors

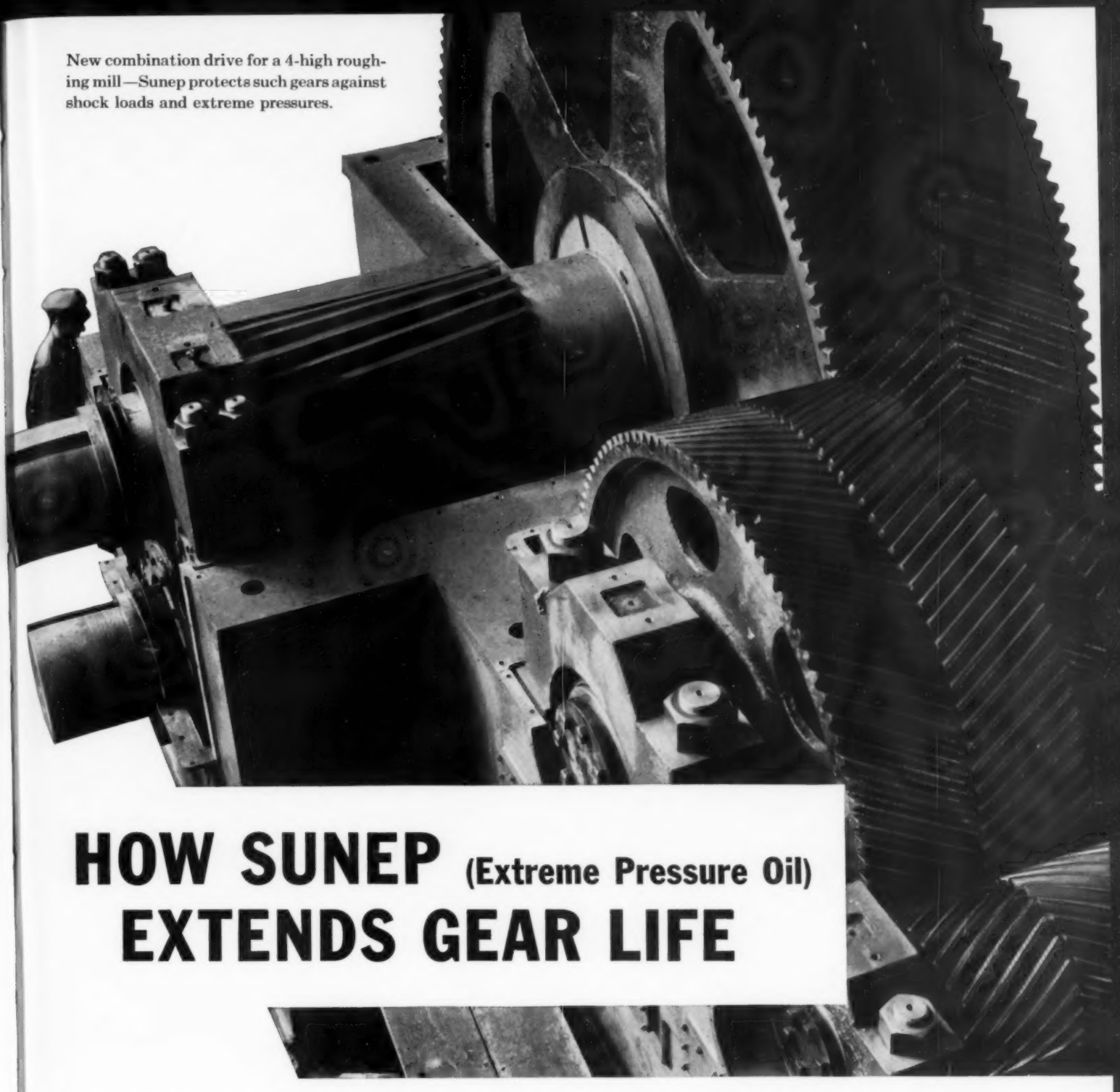
Continuous operation was a prime factor in drawing up specifications for the expansion of the Granite City Steel Company plant in Granite City, Ill. Every piece of equipment, including the electrical wires and cables, was selected on the basis of 24-hour-a-day operation.

High voltage distribution and low voltage control circuits are all wired with Okolite-Okoprene, the mold-cured, rubber-insulated cable that has established a reputation for dependability and long service life in industrial plants as well as utilities. Okolite insulation, which is applied by the Okonite strip-insulating process, is a thoroughly proved high voltage, natural rubber, oil base compound that resists heat, moisture and ozone. The Okoprene sheath, securely bonded to the insulation, provides a non-flammable weatherproof covering unharmed by long exposure to sunlight, acids, alkalies, fumes, heat and most oils.

For additional information on Okolite-Okoprene cables, write for bulletin IS-9000, The Okonite Company, Passaic, New Jersey.

OKONITE SINCE 1878 *insulated cables*

2111



New combination drive for a 4-high roughing mill—Sunep protects such gears against shock loads and extreme pressures.

HOW SUNEP (Extreme Pressure Oil) EXTENDS GEAR LIFE

The advantage of running your machines at high speeds and under heavy loads can be quickly lost if your extreme pressure lubricants turn thick, lose film strength, or cause gears to corrode.

Sunep gives your gears better protection longer. Unlike many E.P. oils, Sunep is made from highly refined, premium grade oils skillfully blended with chemical additives that do not drop out during operation or in prolonged storage. This accounts for several rare user benefits: long life at extreme pressures; absence of corrosion—even on bronze; rust protection for steel parts; clean gears and bearings as a result of the oil's high stability.

Primarily a lubricant for enclosed gears, Sunep has proven to be highly effective on bearings and screws working under extreme pressures. Because of its exceptional clinging characteristics, Sunep guards against metal-to-metal contact during the early moments of machine operation after shutdown. FREE BULLETIN. Tells all about Sunep. Get your copy. Write Dept. IS-2

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GET DEEP-DOWN PULLING
with Stearns Lifting Magnets

A Stearns power-packed lifting magnet provides a tremendous pulling force that reaches well into the body of the load it is lifting. That's why it safely hoists and swings heavy loads even though only a small surface touches the lifting magnet. This is a big advantage for quickly moving bulky units out of cramped quarters. With a Stearns magnet you eliminate straps, slings and other devices — save hours of material handling time.

Stearns lifting magnets are available in standard or special sizes and designs. Nearly 40 years of research and engineering experience is at your disposal. Write today for information.

Check these Features

- ✓ *Permanently sealed magnet coil not disturbed when servicing terminals or pole shoes*
- ✓ *Leads and terminals fully protected against abrasion and shock*
- ✓ *Vacuum-impregnated windings assure long-life electrical operation*
- ✓ *Waterproof construction*
- ✓ *Fast heat dissipation*
- ✓ *Rugged, all-welded or bolted construction*

Here a Stearns magnet lifts an 8,000-lb. casting. Note small point of contact — a real test of deep-down pulling power.

MAGNETIC EQUIPMENT FOR ALL INDUSTRY

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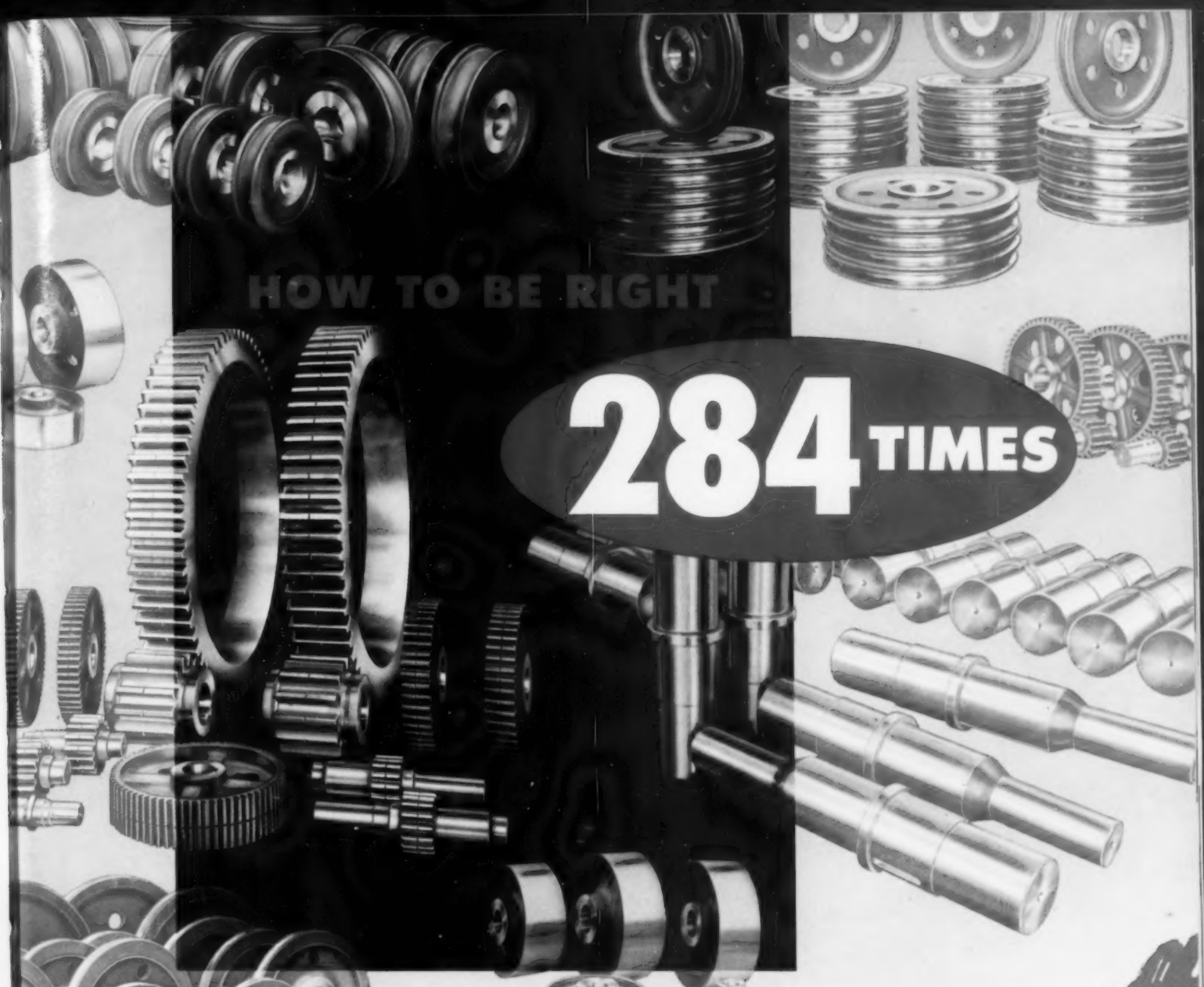

A large mid-west steel company with a reputation for making right decisions installed 284 Tool Steel Process parts on two new ladle cranes.

Substantial operating-maintenance savings previously experienced with Tool Steel Process parts was their reason. They found as others have, for extra long life, Tool Steel Process hardened parts are unequalled. On the two cranes the company specified:

32 AXLES • 60 GEARS - PINIONS • 192 WHEELS (sheave, track, brake)

TSP ... products are hardened by our special process. The file hard surface to the full depth of permissible wear gives maximum wear. The core, refined for toughness and ductility, gives maximum strength.

You receive an absolutely positive written guarantee that TSP products will give a longer life in the same service than any other product.

THE TOOL STEEL GEAR AND PINION CO
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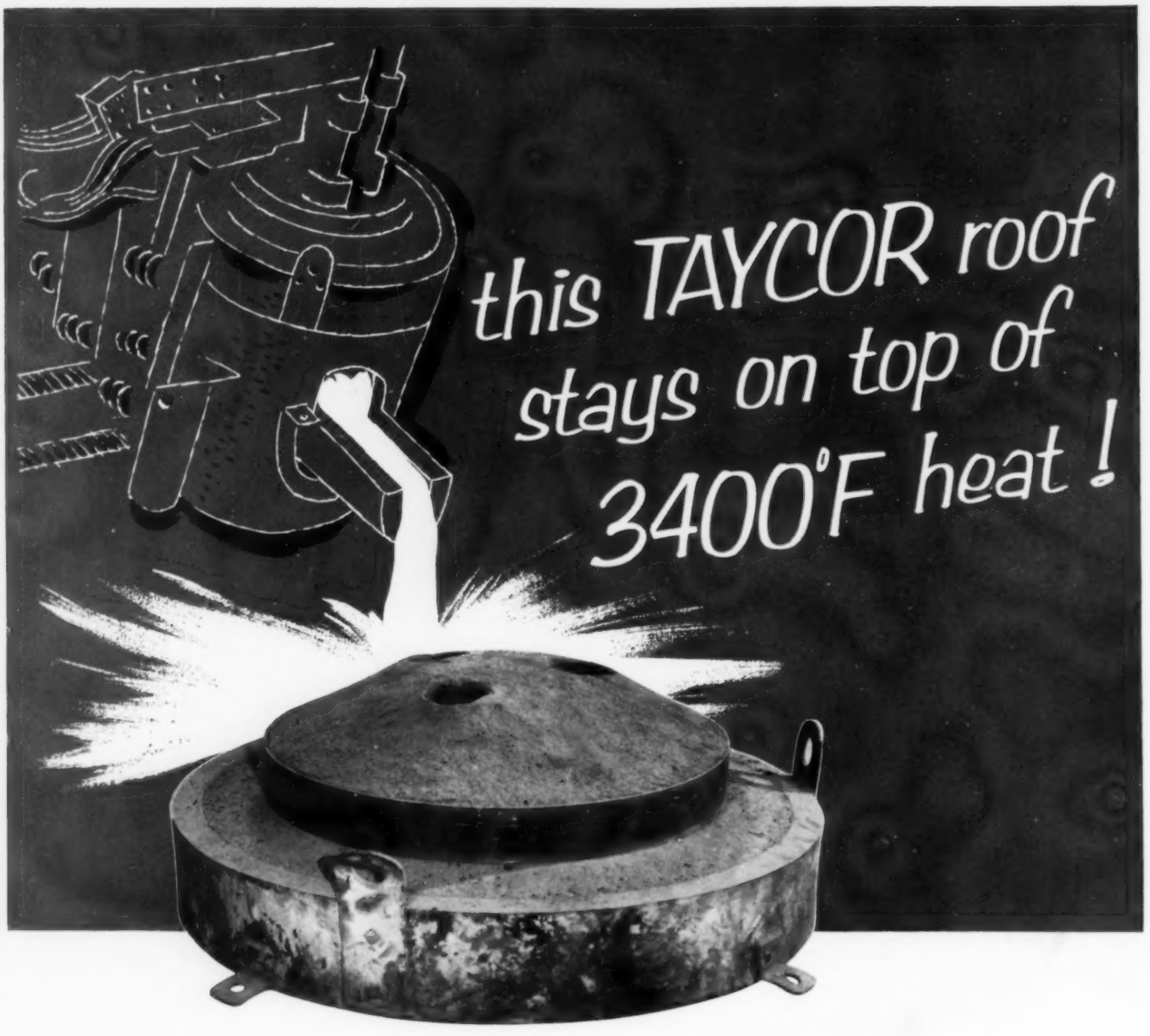

This monolithic roof of TAYCOR Ramming Mix is for a 1000-lb. basic direct arc furnace used to melt a variety of heat-resistant alloys. Furnace operates 16 hours daily at temperatures as high as 3400° F. Extensive tests have been conducted to improve roof life for this severe application. The result of these tests proved TAYCOR Ramming Mix lasted *two to three times longer* than any other refractory. TAYCOR roof life varies from a low of 200 heats to a 900-heat record high, depending upon the alloy being melted.

TAYCOR is our trade name for Corundum-base super-refractory brick, special shapes, cements, patches and ramming mixes. The outstanding properties of TAYCOR are exceptional refractoriness, high hot load strength, superior resistance to mechanical abrasion and attack from iron oxide.

These properties make TAYCOR the ideal refractory for hearths, piers, slot bottoms, front walls, skid rails of forge, heating and heat-treating furnaces . . . for small basic direct arc furnaces operated at higher-than-normal temperatures, requiring long heats . . . for linings of indirect arc furnaces . . . for rammed crucibles of high-frequency induction furnaces. Put TAYCOR to the test in your furnaces. For further information, write direct or call in a Taylor field engineer.

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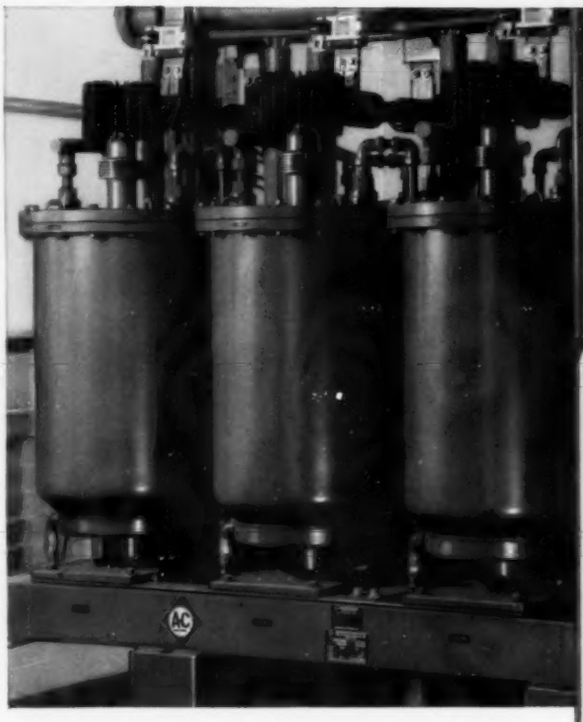
Here's the Rectifier That Needs

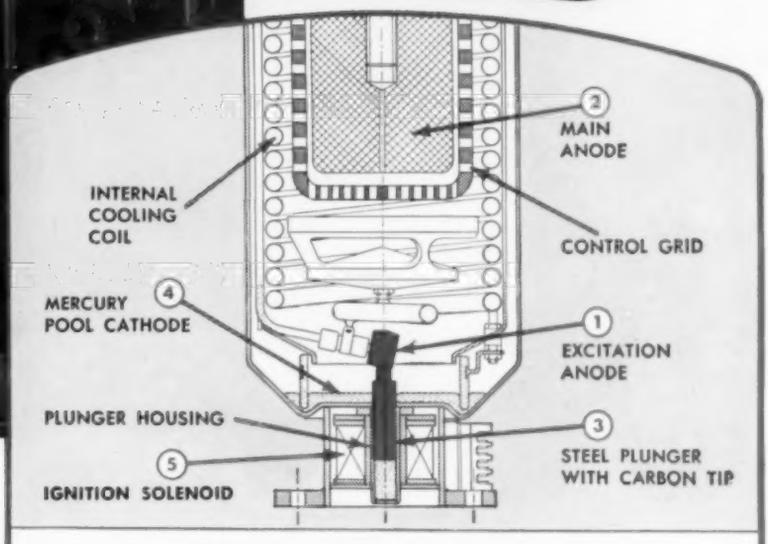
No Delicate Adjustments



This 1000-kw, 6-tube excitron rectifier is typical of units used for heavy-duty service in many industrial plants.

ALLIS-CHALMERS

Mercury Arc Rectifiers



Unique Plunger Starts Continuous Excitation

The excitron tube has an excitation anode ① in addition to the main anode ② . With the excitation circuit de-energized, the steel plunger ③ floating in the mercury pool cathode ④ makes positive contact with the excitation anode (as shown).

When the excitation circuit is energized, the ignition solenoid ⑤ pulls the steel plunger ③ away from the excitation anode ① and under the mercury pool cathode ④ , thus drawing a dc arc and forming the cathode spot, which makes conduction of load current by the tube possible.

If power is interrupted the plunger will float up, contact the excitation anode and automatically re-establish the excitation arc when power is restored.

LITTLE MAINTENANCE IS NEEDED with Allis-Chalmers excitron-type rectifiers. Excitation of the excitron rectifier is continuous, while other types of rectifiers require re-ignition 60 times a second.

Since it is more difficult to start a rectifier arc than to maintain it, the excitron rectifier is much less likely to lose excitation during operation. Momentary dips in supply voltage which are encountered in many supply systems have no effect on the continuous excitation arc.

Years of operation in hundreds of installations have proved the reliability and ease of operation of Allis-Chalmers mercury arc rectifiers. You can get complete information from your nearby A-C office. Or write Allis-Chalmers, Milwaukee 1, Wis.

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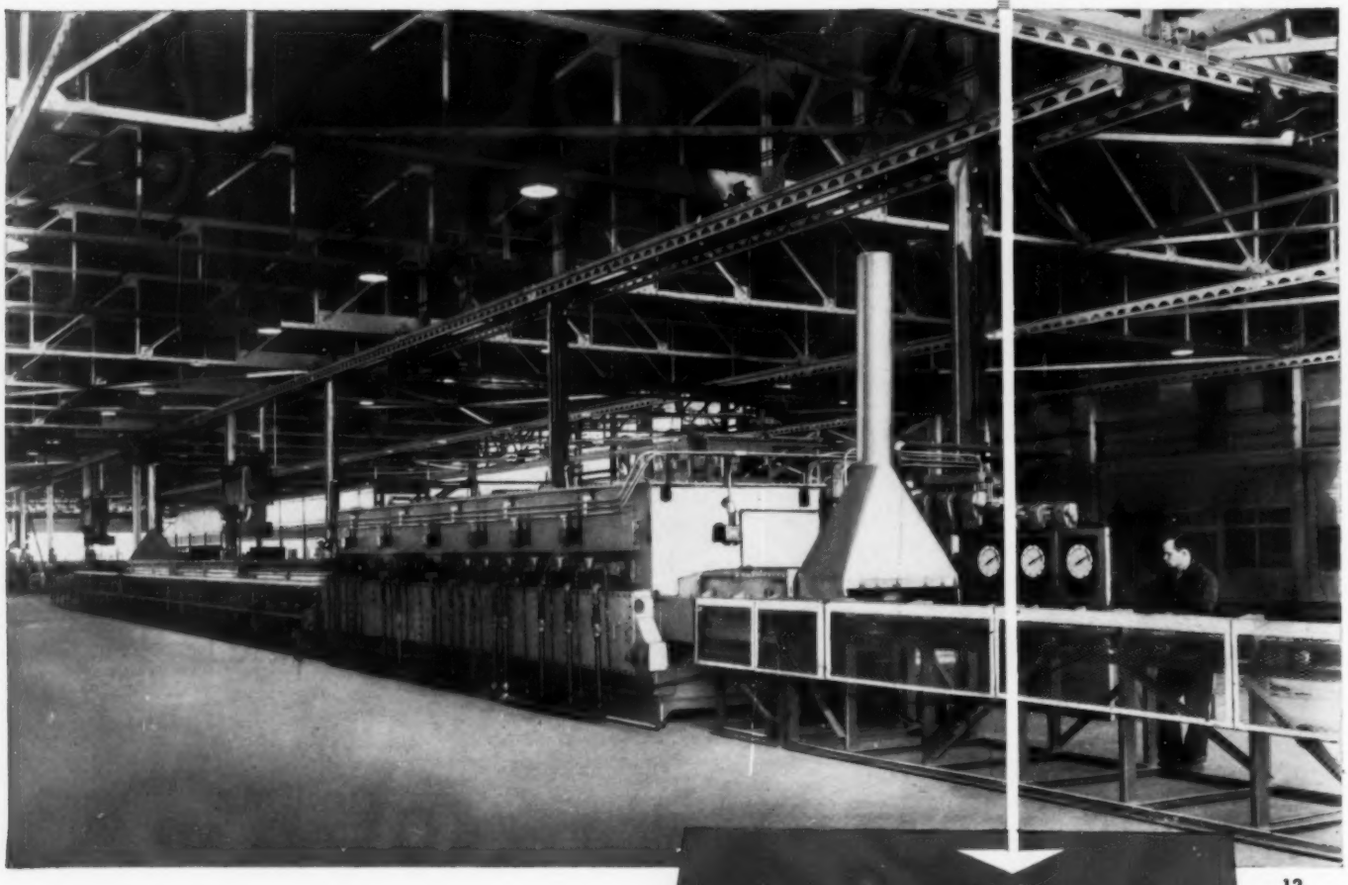
ALLIS-CHALMERS

DREVER

ROLLER HEARTH *Bright Annealing* FURNACES



12

Shown above:

Controlled Atmosphere Furnace
Radiant Tube, Gas-Fired
Capacity, 3,000# /hour
Alloy Tubing ⅛" O.D. to 2½" O.D.
Overall, 176 ft. long x 7'-6" wide

FOR

CARBON and ALLOY STEEL PARTS, BARS or TUBING

Also Available:

Gas or Electric Furnaces for Stainless Steel Annealing with or without Controlled Atmosphere

Installed at the plant of Sawhill Tubular Products, Inc.

DREVER CO.

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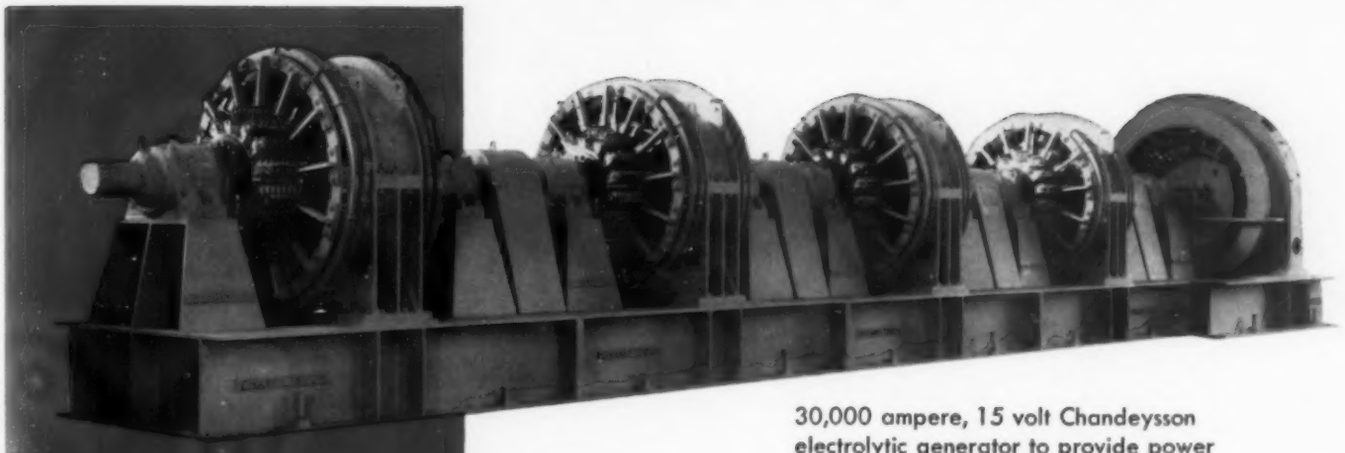

30,000 ampere, 15 volt Chandeysson electrolytic generator to provide power for tin plating at United States Steel's Gary Sheet and Tin Mill.

U S STEEL installs this BIG, NEW Chandeysson ELECTROLYTIC GENERATOR

for a Lifetime of Low-Cost Power Conversion!

How long will this giant motor generator serve dependably, without loss of efficiency? Some Chandeysson units built as long as half a century ago are still in service . . . and this modern Chandeysson is even more efficient and durable than its predecessors.

There's no secret to the amazingly long service life of Chandeysson electrolytic generators. It's simply a combination of the finest, most durable materials; painstaking design for maximum efficiency with a minimum of wear; conservative engineering with ample overload capacity; and craftsmanship by electrolytic generator specialists. To obtain this perfection, all parts of Chandeysson generators except brushes are built in our plant. You can depend on delivery, installation, performance and service.

Whatever your power conversion requirements, you'll save money four ways with a Chandeysson:

1. Use less power
2. Get more out of the power you pay for
3. Be sure of power when you need it most
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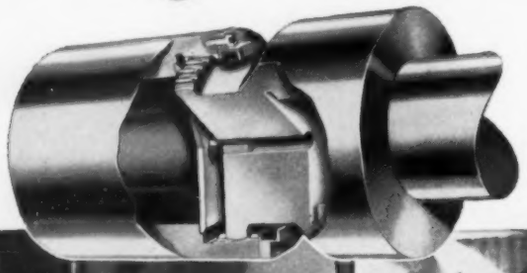
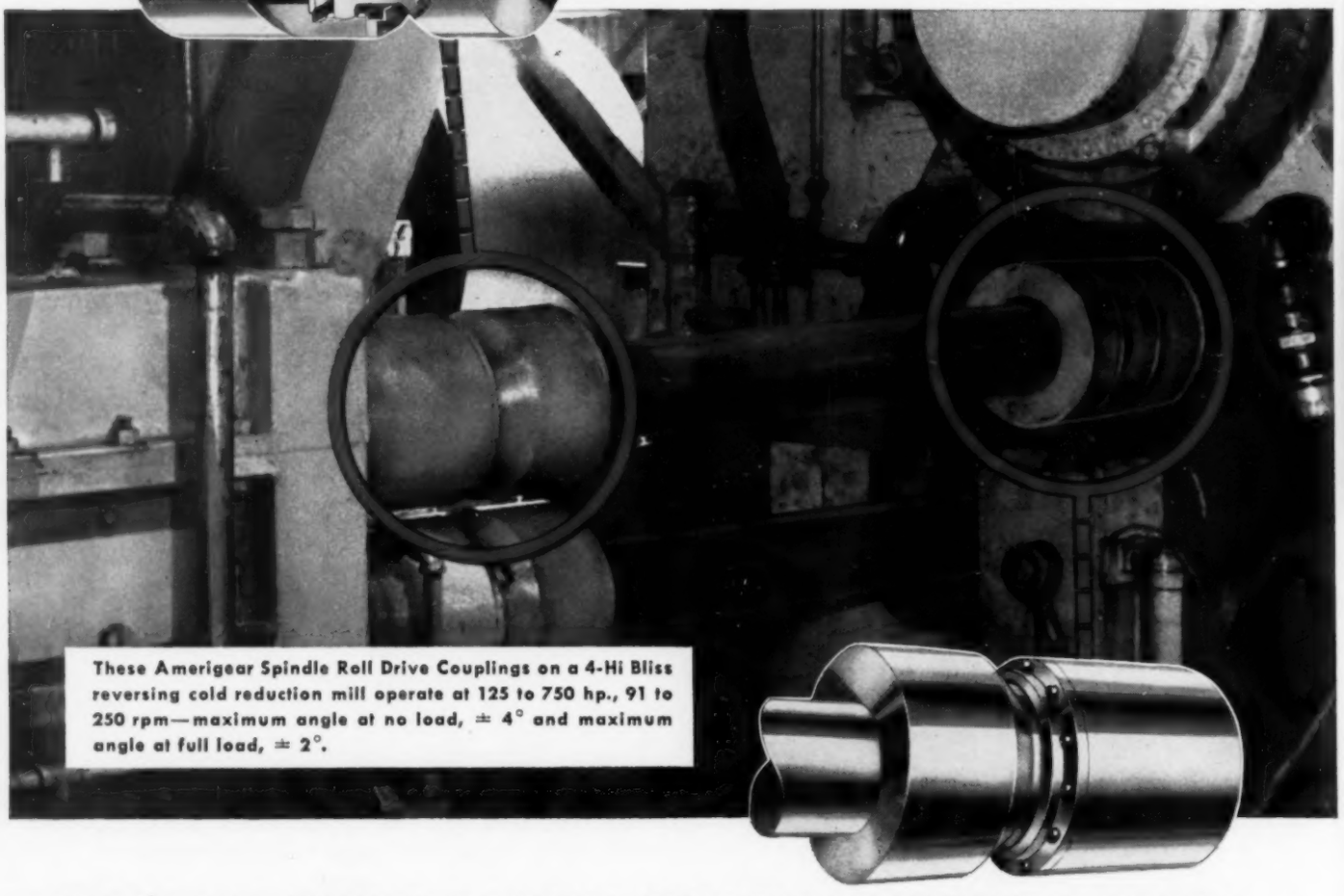
Amerigear® SPINDLE ROLL DRIVE COUPLINGS



. . . RUN LONGER WITHOUT MAINTENANCE
. . . MAKE ROLL CHANGES FASTER



These Amerigear Spindle Roll Drive Couplings on a 4-Hi Bliss reversing cold reduction mill operate at 125 to 750 hp., 91 to 250 rpm—maximum angle at no load, ± 4° and maximum angle at full load, ± 2°.

• HERE'S THE ANSWER TO YOUR HIGH MISALIGNMENT PROBLEMS . . .

Amerigear's Fully-Crowned Tooth Form concentrates the load towards the center of the tooth, eliminates tooth end and tip loading. This permits an extremely high degree of angular and lateral misalignment—up to ± 9° per engagement—with no wear or loss of power.

And By Accomodating For Roll Wear and varying distances between roll centers, Amerigear Spindle Roll Drive Couplings keep your maintenance expenses to a minimum. That's because they're precision-manufactured to transmit power to the rolls smoothly and continuously . . . even after repeated roll grinding . . . *without maintenance.*

Downtime Goes Down, Too because engaging roll end teeth are specially designed for quick assembly and disassembly. So the next time you're in need of flexible couplings for your ferrous or non-ferrous rolling mills, convert to Amerigear — a highly engineered solution to your every high misalignment problem.

Amerigear Engineers are ready to help you design improved operating efficiency into heavy presses, slitters, cranes, reels or other steel mill equipment. Write for Catalog 501 and Bulletin 1052, or attach coupon below to your letterhead.

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2052 St. Catherine St. W.
Montreal 25, Que.

AMERICAN FLEXIBLE COUPLING COMPANY
ERIE, PA., U. S. A.

Please send me further information regarding AMERIGEAR COUPLINGS with the Patented Fully Crowned Tooth Form as described in Catalog No. 501 and Bulletin 1052.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....
Please attach to your business letterhead.

Dept. ISE-999

PRODUCTION CONTINUITY at Detroit Steel's new Portsmouth, Ohio, plant is aided by a G-E engineered power system. Primarily designed for reliability of service and for future expanded capacity, it provides power, for example to these G-E tandem cold strip mill main drives which total 11,500-hp. New facilities provide five times the former finished-product output.

G-E engineering services help Detroit Steel to double ingot capacity at Portsmouth, Ohio

Detroit Steel's sixty million dollar expansion at Portsmouth, Ohio is now complete. The project, an up-to-the-minute example of modern electrification, includes: blast furnaces; open hearth furnaces; soaking pits; blooming and slabbing mill; hot strip mill; pickle line; tandem cold strip mill; and temper mill and processing lines: co-ordinated electrical systems are a vital part of these facilities.

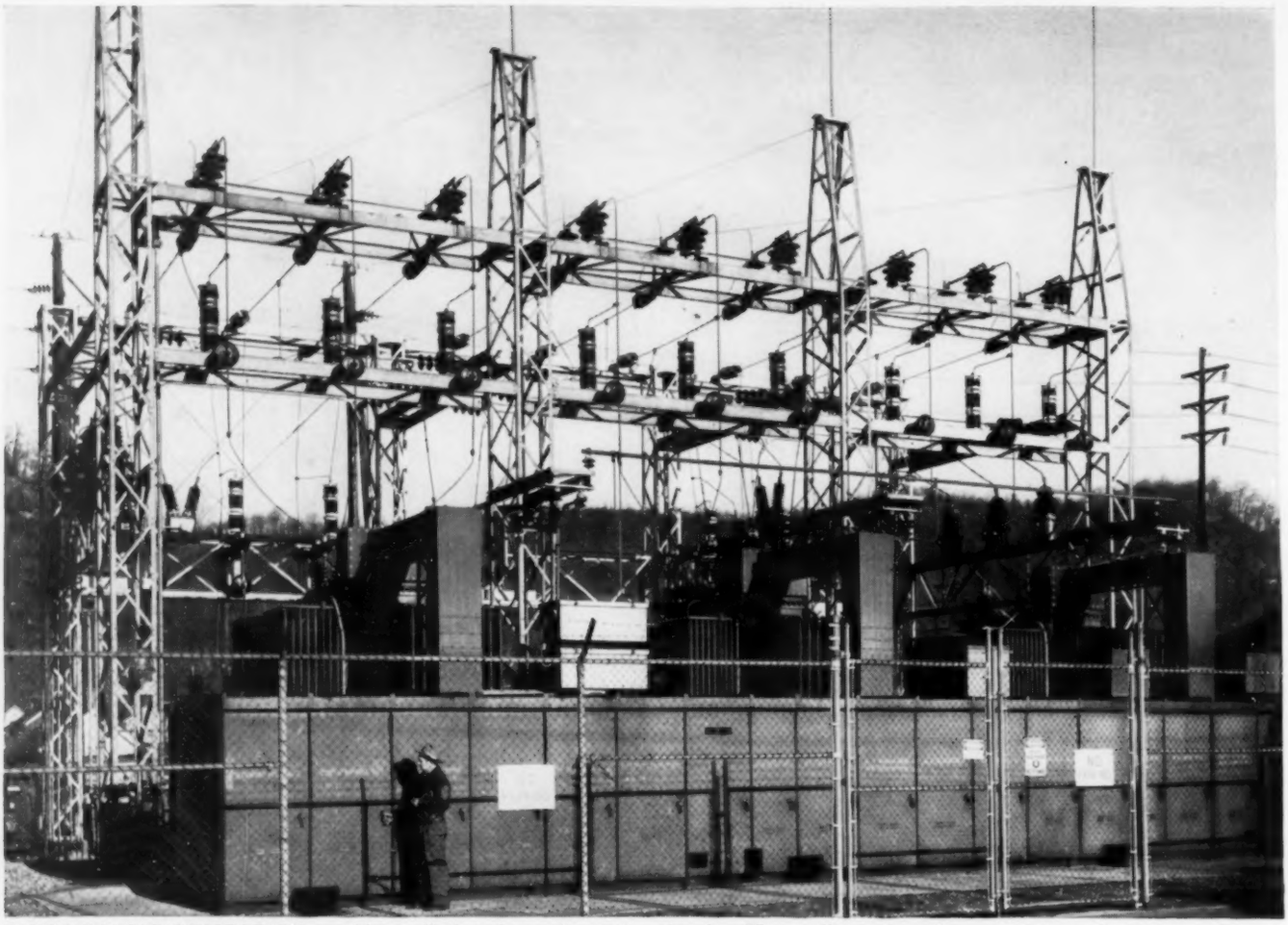
They were engineered and equipped almost 100% by General Electric working closely with such companies as Wellman Engineering Co., John Mohr and Sons, Loftus Engineering Corporation, United Engineering and Foundry Company, Pittsburgh Engineering and Machine Company, Morgan Engineering Company, Stamco, Wean Engineering Company, and Patterson-Emerson-Comstock, Inc.

In the planning stages, G-E application engineers helped define power system requirements. As work progressed, G-E project co-ordinators carefully timed electric equipment deliveries to conform to construction schedules. Finally, G-E field engineers helped supervise the equipment's installation to speed start-up.

The new facilities enable Detroit Steel to double ingot capacity, provide five times the former finished-product output. Practically automatic, the mill employs many outstanding examples of modern power distribution techniques that provide reliability for continuous output.

See Power Distribution Story

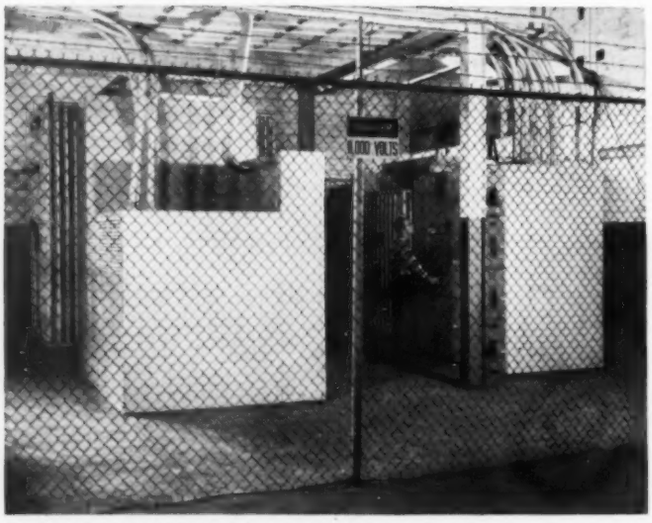
GENERAL ELECTRIC



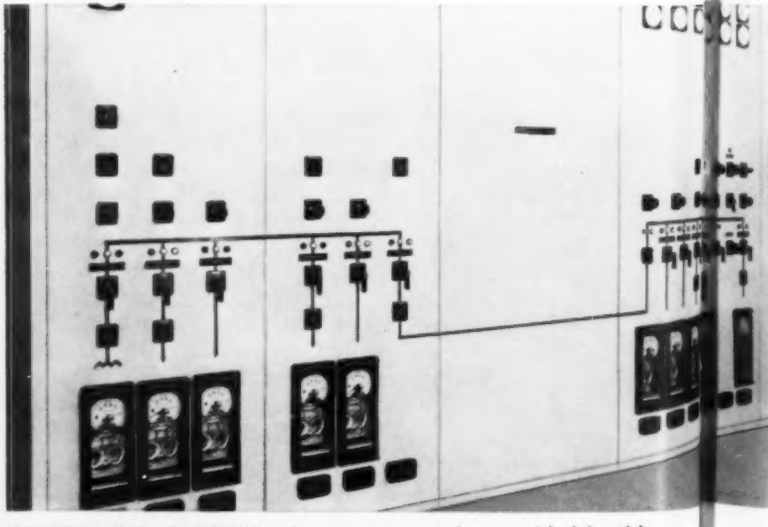
G-E PACKAGED SUBSTATION combines all electric equipment required between incoming high voltage lines and load feeder circuits. Here, all purchased power is brought into system at 34.5 kv and distributed at 11 kv to each major mill or furnace.

Engineered by General Electric for Detroit Steel . . . .

New power distribution system designed for



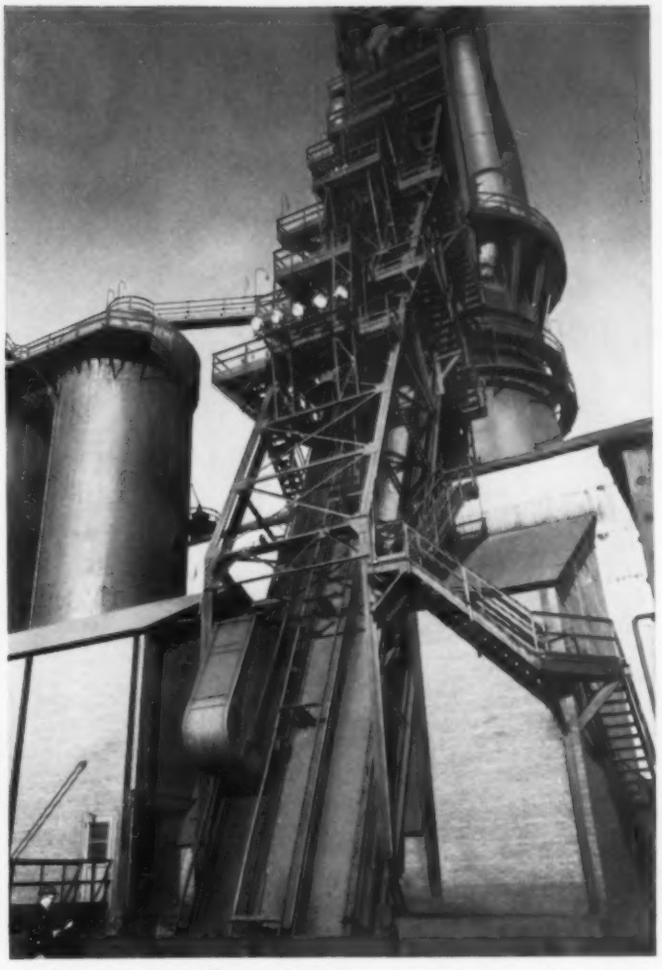
FLEXIBLE G-E INTERLOCKED ARMOR CABLE was used to advantage at these G-E unit substations at the Portsmouth plant. They needed no conduit, cut installation time and costs.



CENTRALIZED CONTROL of power system is provided in this G-E duplex panel. Indicators automatically notify load dispatcher of any trouble.

FACTORY ASSEMBLED, G-E metal-clad switchgear helps protect equipment and personnel, provides space-saving compactness. Circuit breakers are easily removed for maintenance.

UNIFORM VOLTAGE of power distribution system is maintained with aid of this G-E power factor and reactive kva regulator associated with tandem cold strip mill.



PRACTICALLY 100% G-E DRIVES were specified also for operating machinery throughout the plant, including, for example, the 350-cubic foot skip on this blast furnace.

reliability, easy operation, future expansion

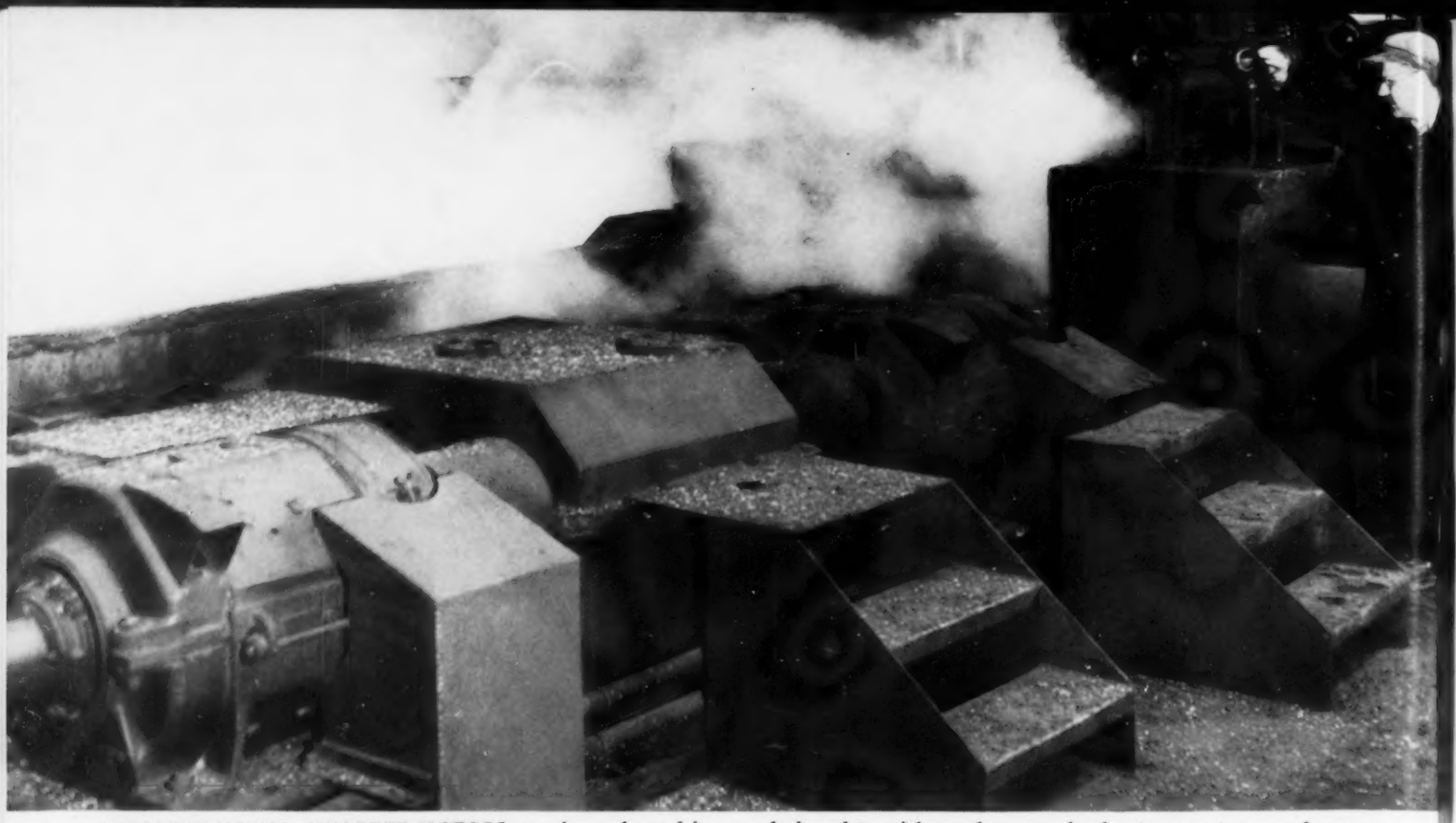
At Detroit Steel's new plant, complete loss of power would cost thousands of dollars an hour in lost wages and production alone. Therefore, General Electric helped design a reliable power system to match capacity, utilizing modern system techniques and equipment.

Close co-operation by all resulted in a more reliable, yet easily operated system, adequate for its job today and ready for future growth.

G-E engineering services are available to *you,* too—in modernizing your electrical systems to achieve higher mill speeds, increased tonnage output, lower operating costs. Contact your G-E Apparatus Sales representative early in your project planning stage. General Electric Company, Schenectady 5, N. Y. 659-103

Engineered Electrical Systems for Steel Mills

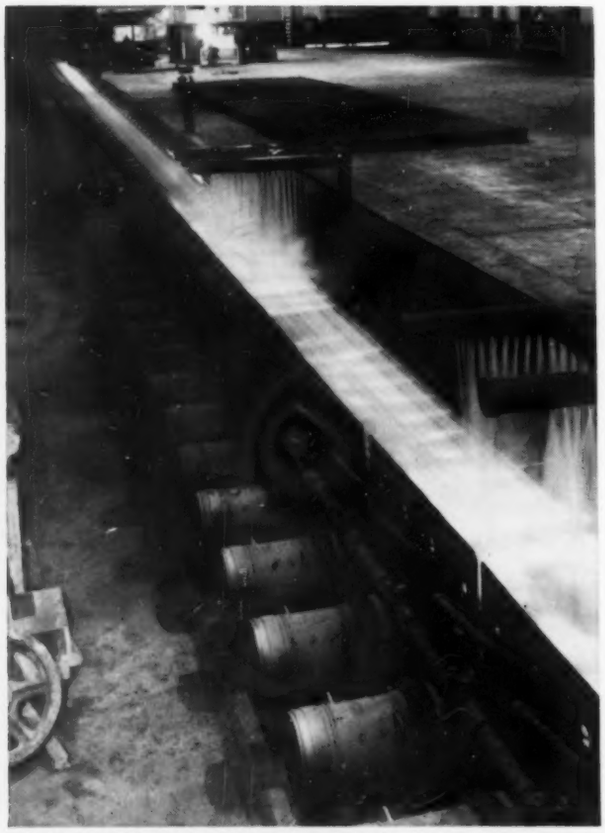
GENERAL ELECTRIC



VERSATILE MD-600 ARMORED MOTORS are shown here driving the roughing mill table. Ruggedly constructed, they are designed to withstand severe shocks, temperatures and reversing conditions. **Write for bulletin GEA-4654C.**

Specified for Detroit Steel . . .

G-E Armored motors take toughest steel-mill jobs — and last longer



MDY RUNOUT TABLE DC MOTORS, better protected against spray, dirt and grease, are easily maintained—last longer. **Write for bulletin GEA-5964.**

General Electric MD-600 armored motors and MDY runout table motors are natural choices in the electrical system for Detroit Steel's Portsmouth, Ohio plant expansion. Their better protection features and greater electrical capacities provide the reliability needed for continuous output. They've built a reputation as tough, dependable steel-mill performers.

MD-600 MOTORS—WELL PROTECTED by heavy cast-steel frames—operate under severe conditions. Whether a foot away from flying red-hot steel or drenched by water spray, they give dependable, low maintenance service.

MDY RUNOUT TABLE MOTORS give top performance under the severest duty cycle. They stop, start and reverse quickly, withstanding mechanical shock and water spray. Their rugged electrical systems and low maintenance features are well-known in the steel industry.

IN ANY INDUSTRY, where the job is tough, these two motors are hard to beat. For more information, contact your nearest G-E Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 810-2

Progress Is Our Most Important Product

GENERAL ELECTRIC

FOR STEEL-MILL APPLICATIONS, like the switching and control operations at Detroit Steel above, G-E Metal-clad switchgear stands up to heavy-duty operation with a minimum of maintenance, and gives maximum protection in case of overloads or faults.

Specified for Detroit Steel . . .

G-E Metal-clad Switchgear for protection and control

General Electric Metal-clad Switchgear best suited for heavy-duty steel-mill control and switching operations

Rough, heavy duty like that encountered in steel-mill applications is exactly the tough treatment for which G-E Metal-clad Switchgear was designed. For switching and control operations like those at Detroit Steel, G.E.'s completely enclosed pre-engineered units offer special advantages.

Vertical-lift design gives clear view of disconnected breaker, and faster-acting breaker-elevating mechanism, part of G-E vertical-lift design, raises or lowers breaker in 30 seconds.

SELF-X, General Electric's new flame-retardant insulation, gives added protection to metal-clad switchgear.

Rigid, all-welded frame withstands shipment stresses better than comparable equipment. Hinged doors make access to totally metal enclosed compartments easy. Advanced magne-blast breaker design requires a minimum of maintenance, and its simplified contact design assures far longer contact life. G.E.'s natural draft ventilation system for each switchgear unit affords optimum cooling for all components.

For details on G-E Metal-clad switchgear, call your nearest G-E Apparatus Sales representative, or write for booklet GEA-5664, to Section 511-6, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

SELF-X INSULATION is used as flame-retardant insulating barriers at all vital points in G-E magne-blast breakers, and Metal-clad switchgear.

VERTICAL-LIFT DESIGN raises or lowers breaker in 30 seconds. Vertical-lift isolates breaker—enables you to SEE disconnect.

MAGNE-BLAST BREAKERS can take the heaviest duty, and because they interrupt arc magnetically in air, are more reliable, need less maintenance.

EASY INSTALLATION is the result of factory pre-assembly and shipment of large units with interconnections already made.

Cleveland Cranes
FOR
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CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
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Crops *and* Shorts

ACCORDING to the American Iron and Steel Institute, the iron and steel industry of the United States spent $680,000,000 for plant improvement and expansion. This makes $6,300,000,000 spent for new equipment and construction during the nine post-war years.

Installed in 1954 were several new arc furnaces, two new blast furnaces, a continuous strip mill, new annealing facilities, a cold mill, and by-product coke ovens. Continuous galvanizing has expanded, with 22 lines in operation, five under construction and nine in the planning stage.

It is estimated that the companies will spend $695,000,000 in 1955. One company is planning a $50,000,000 project for new bar mill equipment, pipe facilities, wire drawing equipment and a continuous galvanizing line. Two other companies plan to increase pipe production facilities. Another plans to spend heavily on their cold rolled strip department. Others are planning on new coke ovens, new tin plate equipment and structural steel mills.

Sounds like a pretty good year.

▲

TWO years ago Bethlehem Steel Co. announced a plan to give $3000 to colleges for each graduate hired by the company. The company has hired 107 graduates from the 1953 and 1954 classes of 30 different schools whose coffers have thus benefited by $321,000. Looks like a good plan. The schools can certainly use the money and Bethlehem seems to be getting its share of graduates.

▲

WE know strain gages are used in a wide field of applications, but their use in a belt around the waist, set to sound a buzzer to warn against overeating, seems to have possibilities.

▲

PREDICTIONS by steel men for 1955 steel production cover quite a wide range, running from the 95,000,000 tons advanced by B. F. Fairless up to a new record of more than 111,000,000 tons mentioned by Admiral Ben Moreell. We don't know who has the best crystal ball, but the entire range is good business.

▲

WHAT with all these "do-it-yourself" activities, we wish someone would write a book on "How to Get Out of Doing it Yourself."

REPORTS from the various companies show some interesting figures for 1954 operations:

	Percentage off 1953		1954 profit, per cent
	Sales	Profit	of sales
U. S. Steel	−16	−12	6.0
Bethlehem	−20	− 1	8.05
Republic	−25	− 7	6.2
National	−23	−38	6.25
Jones and Laughlin	−21	−19	5.08
Armco	−10	+20	7.7
Inland	− 7	+22	7.7

The last column shows steel profits in per cent of sales still lagging far behind industry in general.

▲

INCIDENTALLY, Inland operated at 96.2 per cent and Armco above 90 per cent in 1954, both considerably ahead of the 73 to 75 per cent generally experienced by the large producers. The average for the industry was about 71 per cent.

▲

THE steel industry of the United States started 1955 with annual capacities as follows:

	Net tons
Steel	125,828,310
Iron	83,971,100
Coke	72,684,750

Steel production in 1954 totaled 88,311,652 net tons. Blast furnace production was 58,688,117 net tons.

▲

A lot of people are disappointed in the new federal budget, which still shows a deficit. True, at $62,400,000,000, it is lower than many in the past but there are still many items that might be trimmed.

President Eisenhower wants more spending but he wants the states to do it, accepting more responsibility, helping the cities, and raising debt ceilings. The cities are levying new taxes and at the same time looking to the states for help. The states are looking around for new tax income. Everybody wants to spend money, but preferably someone else's.

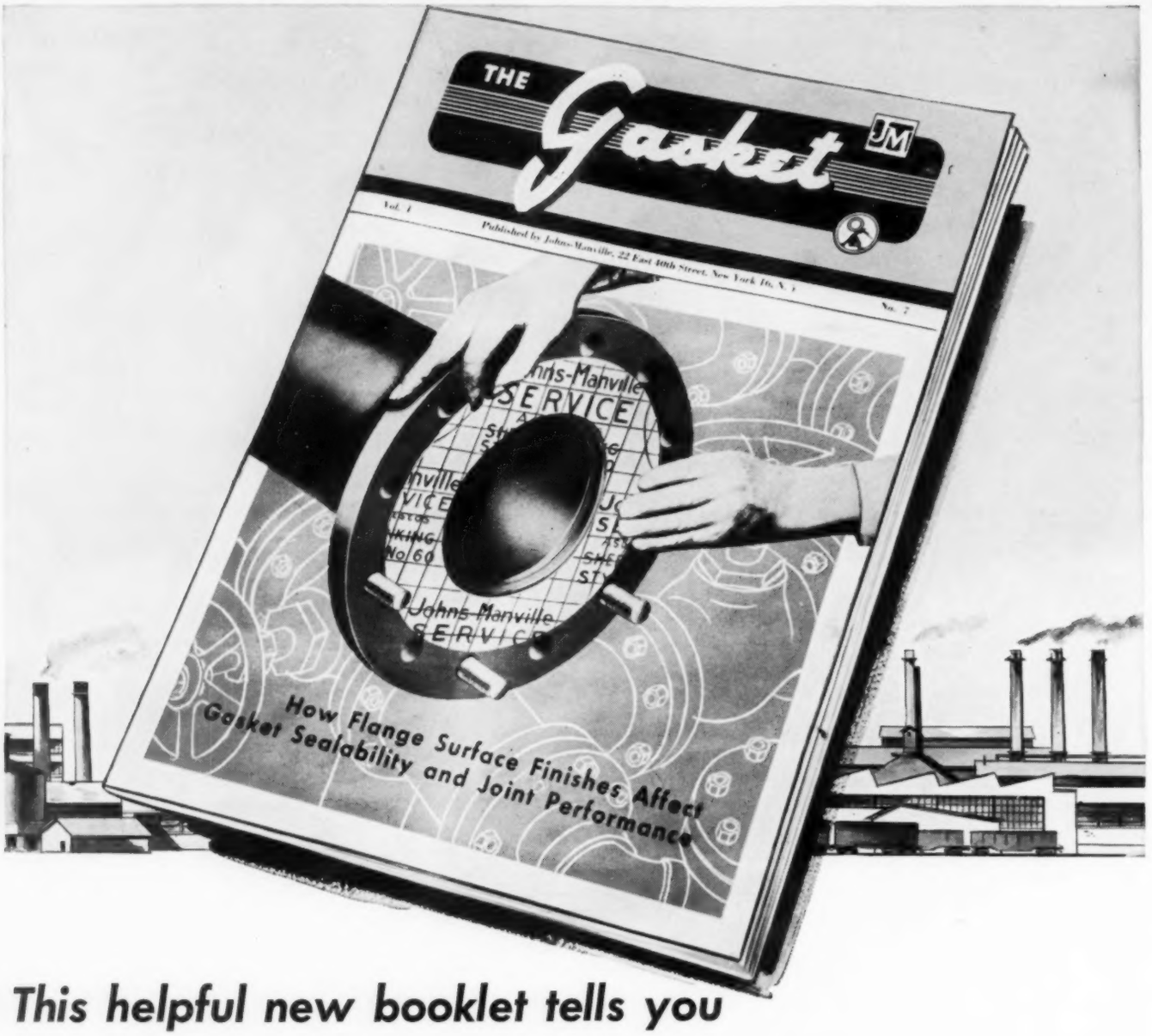
In the end, it's all going to come out of our pockets — yours and mine — and we'd like to spend some money, too, for various things we'd like to have, but we can't spare the money. But if governmental agencies overspend — and feel that it is good or necessary for the economy — why not individuals? Of course, you and I would end up broke or bankrupt, but maybe there's a fairy godmother that will keep us from collective bankruptcy. Let's hope.

▲

THE beer can, which was 20 years old on January 24, hit an all-time production record for the industry of nearly 6,500,000,000 units in 1954, according to Wm. C. Stolk, president of American Can Co. He said the annual use of metal cans per family is now almost 800, compared to 130 in 1903.

▲

AFTER looking at the 1955 models, it looks as if the old "two cars in every garage" slogan is going to change to "two garages for every car."



This helpful new booklet tells you

How flange surfaces affect gasket performance

IF YOU BUY, specify or design joints requiring gaskets, you will find helpful information in this new booklet. It provides a basis for selecting the flange surface finish most suitable for a given gasket. It explains why the right finish makes it easy to form the initial seal and obtain the best joint performance in service.

This booklet is the latest in a series of technical publications issued by Johns-Manville under the collective title "The Gasket." It is based on studies made at the Johns-Manville Research Center, largest laboratory of its kind in the world. It incorporates the long experience of Johns-Manville engineers in the design of gaskets such as asbestos, fibre and composition types, asbestos-metallic and all-metal gaskets.

Booklet offered without charge

To secure your copy of this study, write for "The Gasket," PK-48A No. 7. Address Johns-Manville, Box 60, N. Y. 16; in Canada, 199 Bay St., Toronto 1, Ont.

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Johns-Manville PACKINGS & GASKETS

You can increase production at night by using Crouse-Hinds Floodlights to

"turn night-time into day-time"

Production curves go up when Crouse-Hinds high efficiency floodlights are installed in yards and approaches to industrial plants.

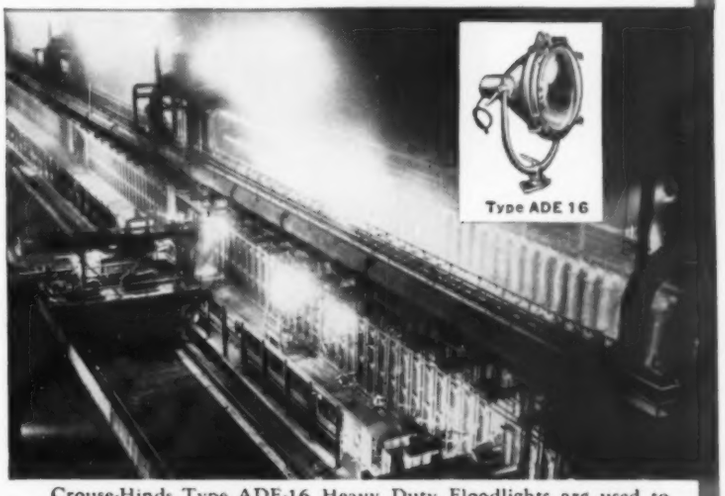
The usefulness of many outdoor areas can be multiplied by flooding them with controlled illumination. Crouse-Hinds all-inclusive line with short, medium, and long range projectors makes it possible to get the right amount of light at the locations where it is needed. This control insures the clarity of daylight where it will do the most good, without wasteful over lighting of unused areas.

Frequently it will cost much less to project light a considerable distance with Crouse-Hinds long range floodlights than to run cable and install local lighting. There are also indoor locations in large buildings where floodlights are the most economical and satisfactory source of light.

Plenty of light is also the most reliable and cheapest form of protection against night prowlers. Sabotage and pilferage thrive in darkness. Crouse-Hinds floodlights project powerful beams of light that bathe all approaches to your property with glaring radiance, compelling everyone to be more visible than in broad daylight.

A Crouse-Hinds floodlighting installation pays off in: (1) increased production; (2) prevention of accidents; (3) protection against dangerous prowlers. Pioneers in floodlighting, Crouse-Hinds illumination engineers have accumulated a wealth of lighting knowledge that is at your service. Write for additional information and ask for your FREE copy of Crouse-Hinds Bulletin 2672 "Lighting Equipment". It contains listings of hundreds of types and sizes of floodlights and explosion-proof, dust-tight, and vaportight industrial lighting fixtures.

A petroleum refinery lighted for round-the-clock operation with Crouse-Hinds Type EVA Explosion-Proof and Raintight Industrial Lighting Fixtures, and Type RLEE-14 Explosion-Proof Floodlights.



Crouse-Hinds Type ADE-16 Heavy Duty Floodlights are used to "turn night-time into day-time" at this plant for 24-hour production.

A parking lot efficiently lighted by Crouse-Hinds Type FLA General Purpose Floodlights.

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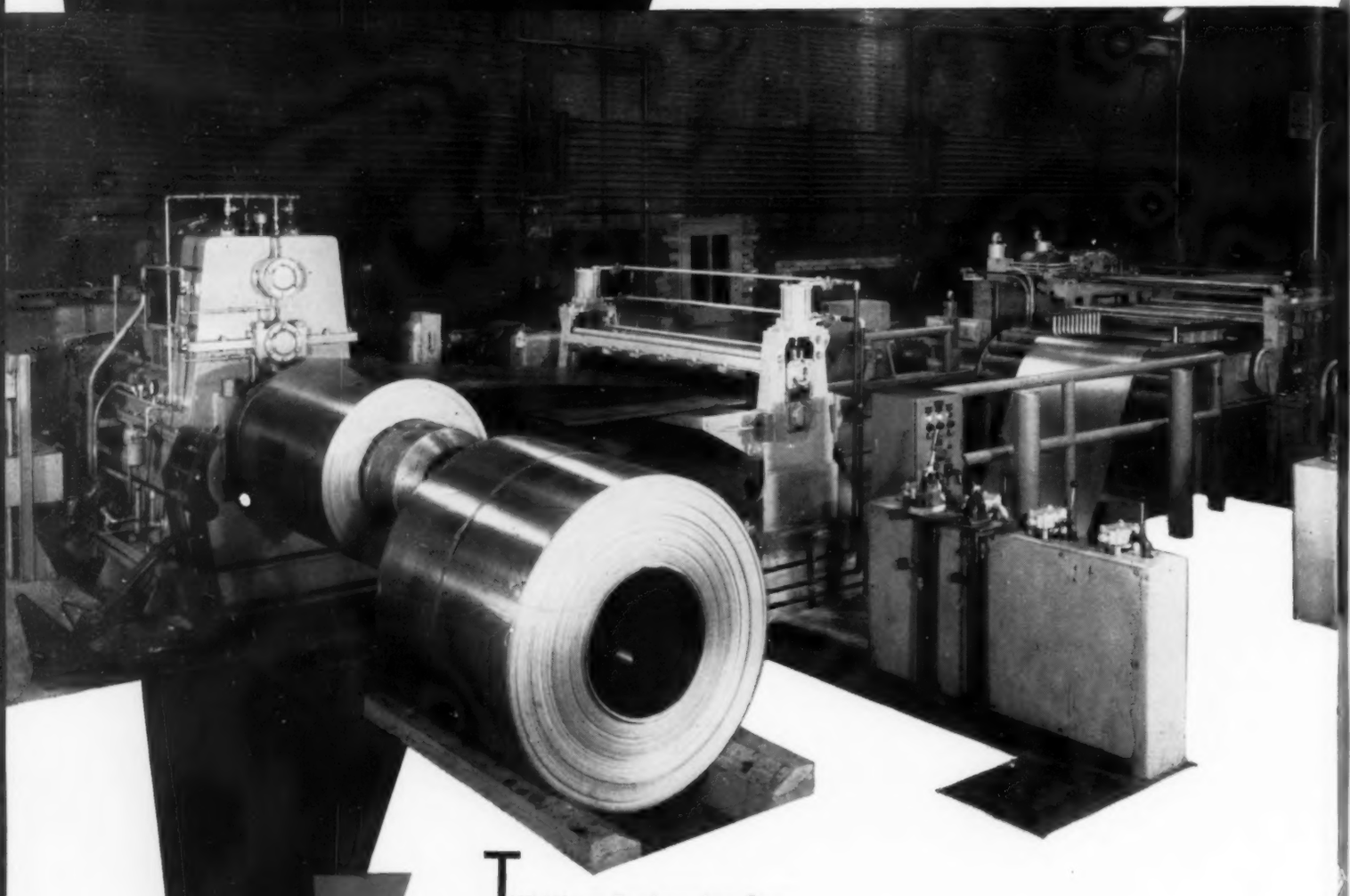

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- 1941 Two 50-ton Lectromelt Furnaces
- 1952 Two 150-ton Lectromelt Furnaces

CONFIDENCE in Lectromelt* equipment has been inspired by Northwestern's nineteen years of experience with these furnaces. As their demand for high quality steel rose throughout the years, they added Lectromelt Furnaces as you see here to produce that steel—efficiently, economically and with the high degree of uniformity they require.

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Taper vs. Straight Tread Crane Wheels

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. . . . perhaps no topic will arouse more controversy than rail or wheel design for cranes . . . . actual test results give factual data . . . .

▲ THE subject of taper tread vs straight tread crane wheels has been discussed by practically every maintenance man who has had anything whatever to do with cranes, and certainly by all crane designers and engineers. Each one is quite certain that his theory is the correct one, and will endeavor to give what, in his estimation, is a very valid reason why he can prove his theory, which is of course based on actual operating practice.

The writer has been one of the same school, who, feeling that he knew the answer to the problem, has set out to prove his theory to be the correct one whenever the occasion presented itself. Nevertheless, in all the discussions and meetings devoted to the subject, no one seems to have actual conclusive evidence to prove his point, whether he favors the taper or the straight tread.

It is next to impossible to obtain accurate data through experiments conducted on runways now in existence, since neither the crane nor the runway can be considered to be in perfect alignment, and it would be a waste of time to base conclusions on anything but an absolutely straight and level runway.

The best results could only be obtained by erecting a runway for this particular purpose, with no tie to any other structure. Likewise, the crane to be used should be a complete new crane with all points checked for alignment, and with the end trucks accurately squared with the bridge, and the wheels accurately machined to uniform diameters.

This of course would involve considerable expense, and while it would be well worth the cost from the standpoint of savings affected in future maintenance, we would all no doubt find it difficult to sell this particular idea in preference to the many other problems which are considered just as important throughout the steel industry.

Therefore it has been the writer's idea for some years, to develop a working model of a crane, with metal wheels operating on a metal track, using both taper and straight tread wheels, changing the wheels to obtain every conceivable operating condition.

This should involve taper tread driver wheels used with straight tread idlers; taper tread idlers used with taper tread drivers, and straight tread wheels used for both drivers and idlers.

The model should also be designed to permit adjustment of the crane span as well as of wheel spread on the end trucks in order to determine exactly what ratio would give the best operation.

One point should be clarified on the question of the types of wheels to use on cranes. If crane runways were in perfect alignment, with no outside forces tending to create misalignment, and if the crane is properly designed as to ratio of wheel spread to crane span, there would be absolutely no reason for installing taper tread wheels on any crane.

The reason for this is that clearances between rail head and wheel flanges could be reduced to a minimum, and this would therefore eliminate any tendency to throw the crane out of line to a skewed position on the runway. It is this skewing of the crane that causes continual riding of the flanges, and thus shorten the life of both the wheels and the rails.

But since accurate runway alignment is not the general rule, and we all recognize the difficulty of maintaining it (particularly in old buildings), we are faced with the problem of finding a solution. The first thing to determine is which installations call for taper treads and which call for straight treads, for certainly neither

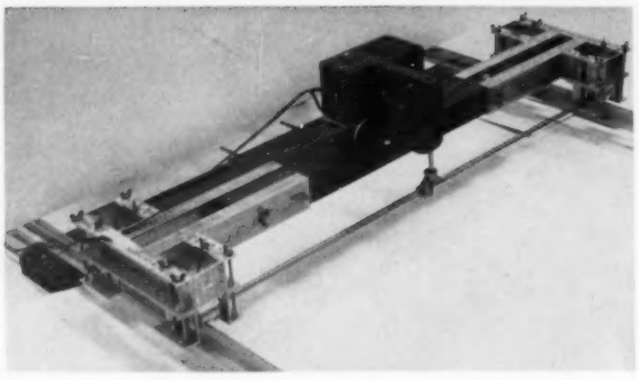

Figure 1 — Model crane was set up with crane span at 37½ in. which is equal to a 75-ft span in the field.

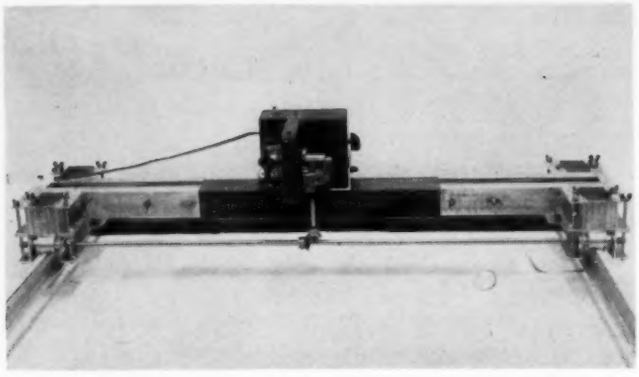

Figure 2 — Wheels of model had a flange width wider than the normal ratio.

type in itself will correct all the evils we have experienced.

There are two phases to this problem. One involves the erection of new cranes on old runways, or the replacing of wheels on old cranes. The other pertains to the erection of new cranes on new runways.

However, the problem of keeping cranes and runways properly aligned is present regardless of whether it be in connection with old or new structures. The question of taper vs straight tread wheels is therefore considered purely from a maintenance point of view commensurate with good operation.

Figure 1 shows a plan view of the crane model as finally completed. It can be adjusted from a span equivalent to 50 up to 75 ft, and permits the wheel spread adjustable anywhere from 11 to 16 ft.

The model is electrically operated, at speeds from 1 to 30 fpm and is built to a scale of ½ in. to the foot.

In most of the studies, the crane span was set at 37½ in., which is equivalent to a 75-ft span in the field, and the wheel spread set at 16 ft. It stands to reason that the best results in crane operation would be obtained with a long wheel base, which would be improved the nearer the ratio to bridge span approaches or even exceeds 1 to 1.

This can readily be visualized by considering conditions for railroad cars, where the length between end trucks far exceeds the gage of the rails, giving the best operating condition possible under the circumstances.

It would be rather difficult to detect any change in the position of the crane on the rails by the use of the standard width of taper or straight wheels, (either ¾ on a side or ⅜ in. as the case may be).

Therefore the taper wheels were made six times the actual width between flanges or the equivalent width on the runway of 24 in. compared with the commonly used standard of 4-in. for taper wheels. This, without question, makes it possible to observe the lateral movement of the crane, whether it be properly aligned or skewed to any permissible degree. The taper was made 1 in 16, which some designers erroneously consider the correct standard. Since this paper deals only with the question of taper vs straight treads, the question of correct amount of taper will be left to later discussions. Figure 2 shows a front elevation of the same model.

In the case of straight tread wheels, they were made 8.3 times the actual width between flanges, or the equivalent width on the runway of 24 in., compared with the commonly used standard of 2⅞ in. for straight tread wheels when used with 100 lb rails.

To more clearly show the theory of taper treads, let us look at Figure 3. This shows an enlarged diagram of a taper tread wheel on either end of a drive shaft. The amount of taper shown is of no importance in this diagram. What is important is the relative position of each increment across the face of the wheel, compared with the same increment on the wheel on the opposite end of the drive shaft.

Let us assume the wheel to be 30 in. in diameter on the large end and 26 in. in diameter on the small end. Dividing up the width of wheel into four equal sections, 6 in. apart, gives us even figure diameters of 29, 28, and 27 in. The periphery of each of these diameters is given below the wheels.

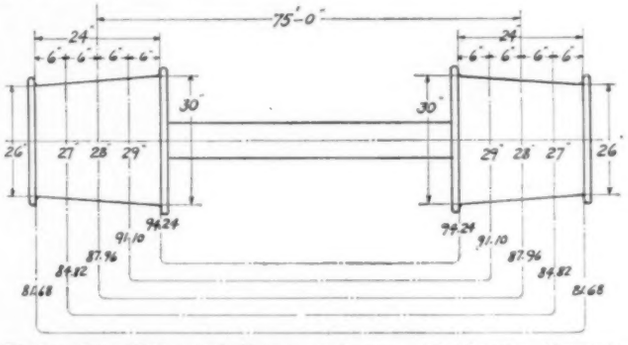

Figure 3 — Enlarged diagram shows variation in diameter of taper tread wheels.

With the wheels centered at the 28-in. diameter increment, it stands to reason that at each revolution of the wheel the crane would travel the length of the circumference of 28-in. diameter, or 87.96 in. This would pertain to both ends; therefore the crane remains definitely in line.

Now assume some lateral force (such as pulling of cars, etc) should pull crane to one side of the runway. We could then have the right wheel bearing on the rail at the 29-in. diameter increment and the left wheel bearing on the 27-in. increment. Therefore, in one revolution the right wheel would travel 91.10 in. while the left wheel was traveling only 84.82 in. The crane is now skewed.

Figure 4 shows the wheel skewed on the runway and clears up the reason a skewed crane cannot remain in this position, since the wheels are no longer in parallel

alignment with the rails. This can be noted by the extremely heavy line shown as the center of a crowned rail, with the wheel shown at an angle.

In this you will note that there develops a spiral motion of the wheel on the rail, which tends to weave the crane. As this spiral action moves this particular wheel from the 29-in. increment it naturally continues until the heavy line reaches the 28-in. center increment, after which the angularity of the wheel reverses.

The opposite end wheel then reaches the 29-in. increment at the same time this wheel reaches the 27-in. increment and this action continues until one or the

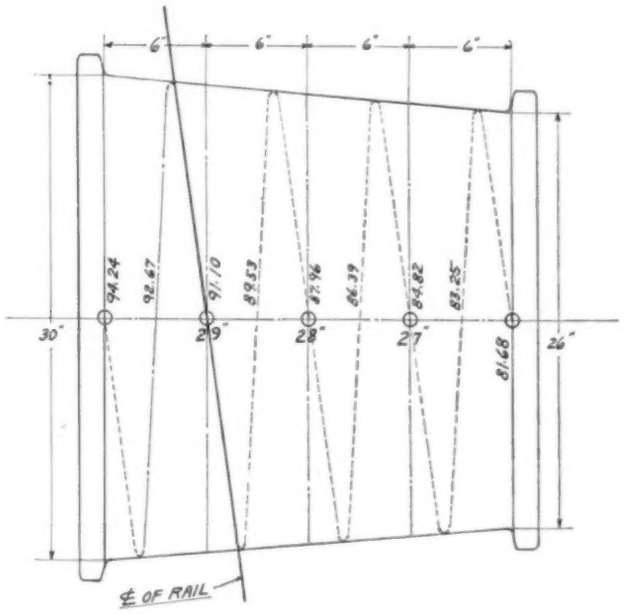

Figure 4 — A skewed crane with taper wheel cannot remain in this position while running on the rails.

other wheels strike the flange when the same reverse action takes the crane back to its original position.

Therefore, the wear on the inside surface of either flange and on the sides of the rail head is reduced to a minimum.

This is more clearly illustrated in Figure 5, which shows the same action as applied to both wheels on either end of the drive shaft. While the idlers are not as a rule connected with a shaft, they do have influence on the action of the crane when using taper tread wheels. There is the same action developing whether they are connected with a shaft or not.

The same cannot be said for straight tread wheels which, once skewed, cause the crane to remain in that skewed position for practically the entire length of runway so that it cannot be brought back into proper square alignment until it strikes the bumpers at end of the runway.

The location on runway where crane would be back in proper alignment depends upon the amount of wear developing to increase the clearance between the rail head and the inside face of the flanges of the wheel.

However, the total amount of weaving on the runway with taper tread wheels is nothing to become excited about since the maximum distance one end of a 75-ft 0-in. span crane can move ahead of the opposite end is only 8½ in., with the nominal clearance of ¾ in. on either side of the rail head.

Figure 6 shows the application of a taper tread wheel on a standard crowned rail. This same condition also applies to the wheels of a railroad car, with the outer flange eliminated. A point contact develops on the crowned head, which is only a satisfactory operating condition for a taper tread as long as the rail head maintains its crown.

Figure 7 shows the application of a taper tread wheel on a crowned rail and a dotted line to indicate the wear eventually developing after long service.

Figure 8 shows the application of a taper tread driving wheel when used with straight tread idler wheels. The dotted lines show the resultant wear to the rail under this operating condition.

It results in a tapered surface meeting a horizontally worn surface, establishing an edge at point marked "A," which reduces the bearing surface for each. Therefore, it is the writer's contention that when taper tread wheels are used for the drivers, the idlers should also be taper tread. Proper provision however should be made for the end thrust resulting from this design.

Figure 9 shows a straight tread crane wheel as applied to a crowned rail. This is the condition prevailing on all our cranes except those where heavy loads demand the use of the 171-lb flat head rail. This, as in the case of a taper tread wheel, also develops a point contact on the crowned rail, which means high concentrated load at that area.

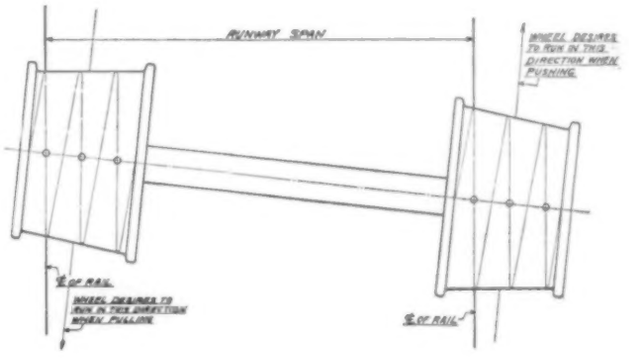
RUNWAY SPAN
WHEEL DESIRES TO RUN IN THIS DIRECTION WHEN PUSHING
℄ OF RAIL
WHEEL DESIRES TO RUN IN THIS DIRECTION WHEN PULLING
℄ OF RAIL

Figure 5 — Skewed crane with tapered treads will weave as it moves along the runway.

It seems only natural to assume that, with the tendency throughout the steel industry to overload cranes, the unit pressure on some of the wheels in contact with a crowned rail has much to do with spalling of the wheel surface, and the resultant short life for both the wheel and the rail.

Figure 10 shows a contoured crane wheel on a crowned rail. This, in the writer's opinion, might be satisfactory for a crane bridge rail, where the trolley span can be definitely maintained, but cannot be recommended for a crane runway that has any chance of getting out of line or span.

This type of contour wheel allows no lateral misalignment of runway. It is therefore recommended that where this wheel is now in use on runways difficult to maintain and where maintenance of wheels is a problem, a change to another type wheel might be the answer.

With this type wheel considerable wear to both wheels and rails would occur, since each increment across the face of the wheel, as shown in the diagram,

has a different peripheral speed, causing forward or reverse slippage, depending upon which increment develops the driving force moving the crane. This difference could be as much as ½ to ⅝ in. for each revolution of the wheel.

Therefore, as a result of the studies up to this time, the design of rail shown in Figure 11 is presented. In this design, the use of flat or straight tread wheels with flat head rails would distribute the loading over a wide face and thereby reduce the concentrated unit pressure normally developed with a crowned rail.

We have had experience with the 171-lb flat head rail where heavy loads are the rule, as in the case of large hot metal ladle cranes, and we would not recommend crowned rails for this type of service.

Since this is a condition that eventually results from long service or excessive wear, the question arises, "Why not roll the rail as shown and have this ideal condition from the start?" Certainly distribution of the load over a wider section of both rail and wheel should lengthen the life of both.

There is some question in the writer's mind as to why the crowned rail has continued to be used for practically all runways except those calling for the 171-lb flat head rail.

Increased loads are continually being applied to many of our medium size cranes, those in the range of 50 to 150 tons capacity. Yet the maintenance on wheels and crowned rails is just as troublesome as the larger ladle crane loads would be if flat head rails were not used where these loads demand other than a crowned rail.

A great deal of discussion has taken place during the past few years regarding the advantages of taper tread wheels and the amount of taper to use. The question whether a greater taper increases weaving or tends to eliminate much of the weaving has also been discussed.

This can be clarified to some extent by means of four

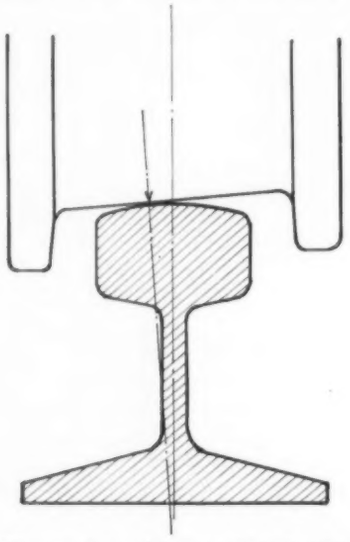

Figure 6 — A taper tread wheel on a standard rail results in point contact.

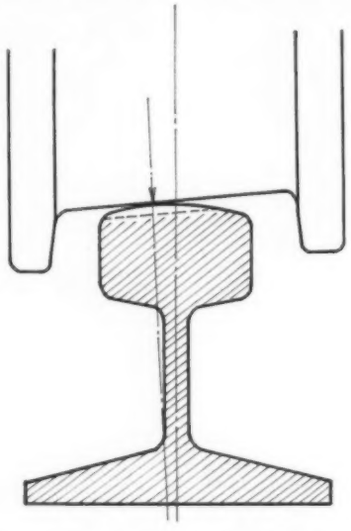

Figure 7 — Crowned rail will wear to a straight line with taper tread wheel.

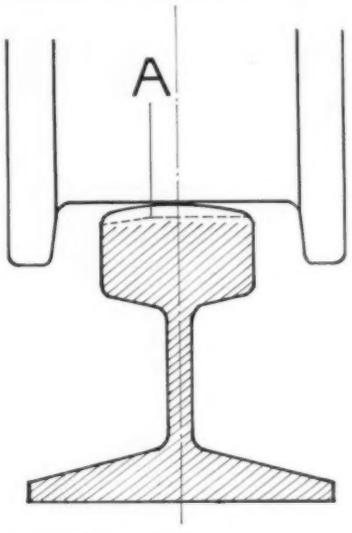

Figure 8 — Sketch shows wear which occurs with taper tread driving wheel and straight tread idler wheel.

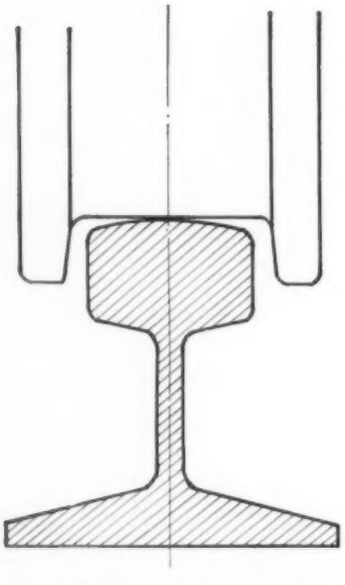

Figure 9—Straight tread wheel develops point contact with all standard rails except the 171-lb flat head rail.

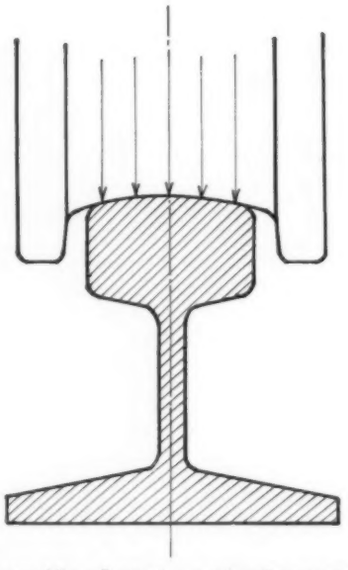

Figure 10 — A contour wheel on a standard crowned rail gives line contact only when the span is perfectly maintained.

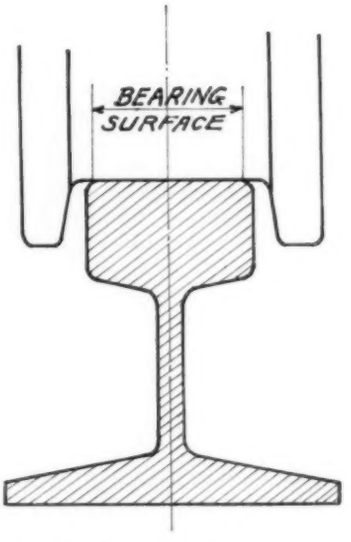

Figure 11 — Best wear would probably be obtained with a straight tread wheel on a flat head rail. Good gage must be maintained.

diagrams showing in four steps a method of illustrating the principle of weaving when using taper tread wheels.

Figure 12 shows a rough diagram of a crane bridge end trucks where vertical rollers bear against the inside face of the rail head, with the crane load carried on the conventional type wheels, but without flanges. This condition, while not recommended for large cranes, would eliminate practically all weaving, other than that resulting from the operating clearances necessary.

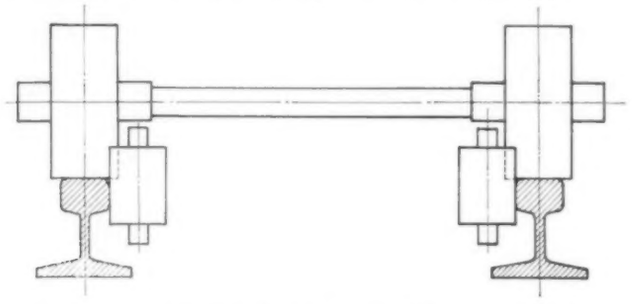

Figure 12 — Vertical side rolls could prevent skewing.

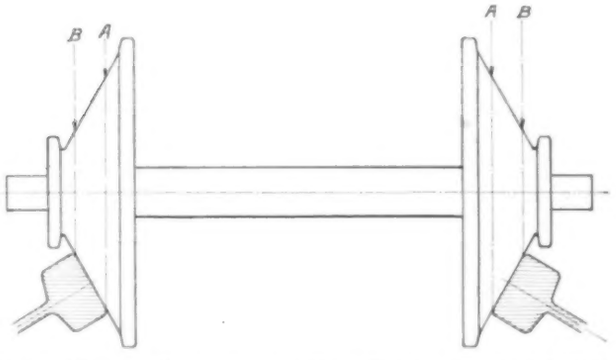

Figure 13 — A steep taper with inclined rails would eliminate weaving but would also give excessive slippage at points A and B.

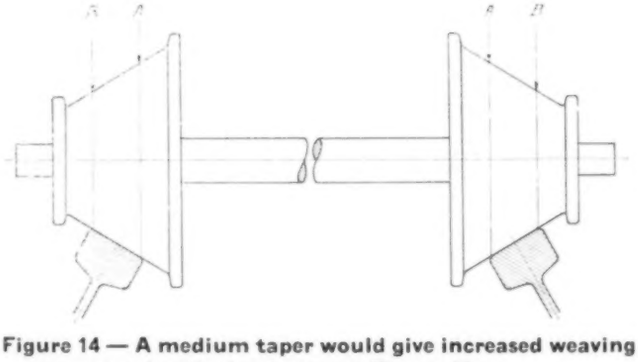

Figure 14 — A medium taper would give increased weaving compared with the design of Figure 13.

Figure 15 — A taper of one in sixteen gives a maximum of weaving.

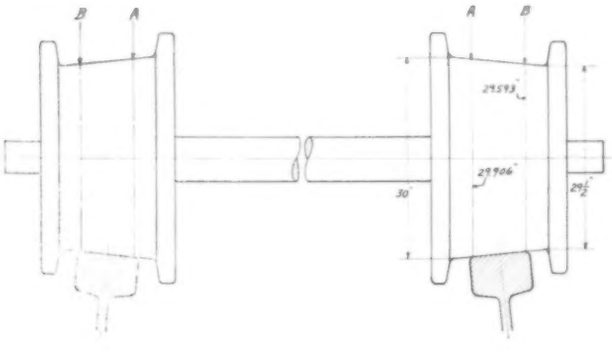

Figure 13 shows the second step with the use of wheels with excessive taper, and flat head rails located perpendicular to this extreme taper. This design prevents weaving, and would make it practically impossible to skew the crane. However, it would develop very excessive slippage at the points marked "A" and "B."

Figure 14 shows the third step with considerably less taper, but still a far greater degree of taper than could be recommended as good practice. A flat head rail is also shown perpendicular to the taper. This wheel would develop less slippage at points "A" and 'B" than would the design shown in Figure 13.

Figure 15 gives the fourth step, showing what is usually considered as standard taper of 1 in 16, which would develop less slippage at points "A" and "B." Even with this so-called standard taper, there is a forward or reverse slippage between these two points of approximately $\frac{15}{16}$ in. for each revolution of a 30-in. diameter wheel, when operating on a $2\frac{1}{2}$-in. width of rail head.

It must be realized, however, that where the diagrams show flat head rails in contact with taper tread wheels, the writer has considered this from the standpoint of a worn rail, which is usually the condition existing after rails have been in service for some time. The only way to prevent this condition from developing would be to renew the crowned head rails whenever they show the slightest amount of wear.

It is unfortunate that the publication of this paper makes it impossible to show motion pictures of the model crane in operation. Motion pictures have, however, been made of the crane in motion, which clearly demonstrates the points presented elsewhere in this paper.

The first demonstration covered the crane operating on a metal track with straight tread wheels on both the drivers and idlers. (Bear in mind the wheels in this case of straight treads are 8.3 times the normal width ordinarily used on the runway). When the crane was moved laterally against the flanges, it operated for the entire length of the run by continually bearing against the flanges until it struck the bumpers at the end of the runway.

It might be well to mention that the runway in this case is 12 ft in length. This is equivalent to an outdoor runway of 288 ft and presents quite a satisfactory comparison for study.

The crane was next skewed to the maximum angle permissible with the extreme width of the wheels used in this model. The crane continued to move in this position and showed no tendency to change its position until it reached the end of the run.

As mentioned in the early part of this paper, wheels, both taper and straight treads, were made considerably wider than is consistent with good operation in order to more clearly demonstrate the action while in operation.

Where straight tread wheels are made with only $\frac{3}{8}$-in. clearance over the head of a rail, it stands to reason that there cannot be very much skewing of the crane. However, this condition demands great accuracy in runway alignment.

The next demonstration covered the crane operating on a wooden track, with wheels of the extreme taper shown in Figure 13. Taper treads were used for both drivers and idlers. This set-up seemed to give the crane a strong tendency to remain centered. It was practically

impossible to move it to one side of runway, or to skew it in the slightest degree.

A condition arises in this case where the lateral forces on one side of the runway, caused by the extreme taper of the wheels, tends to react against the same forces on the opposite side of the runway, with the result that there is no possibility of the crane changing its centered position on the runway.

The next demonstration covered the crane operating on a wooden track, with wheels of less taper, as shown in Figure 14. Taper treads were used for both drivers and idlers. This medium taper allowed the crane to move slightly to one side of runway, and also allowed for a slight skewing, but there is a definite tendency of the crane to right itself in a short distance.

There is no tendency for the crane either to remain against one set of flanges or to stay in a skewed position for the entire length of runway, as is the case with straight tread wheels.

The next demonstration involved the crane operating on the metal track with 1 in 16 taper tread wheels for both the drivers and idlers. (Bear in mind the wheels in this case of taper treads are six times the normal width ordinarily used on the runway.) Setting the crane on absolute center, there was no tendency for the crane to move to either side of runway. It remained on dead center from one end of the runway to the other. This same condition prevailed when a heavy load was placed on one end of the bridge; no skewing or weaving occurred.

The crane was next moved over to one side of the runway, with flanges tight against the heads of the rails. After traveling an extremely short distance, the crane immediately started weaving, as shown in Figure 5, and continued this for the entire length of the run.

The crane was then skewed to the maximum position permissible with the extreme width between wheel flanges. The crane righted itself by the time it had traveled about 3 ft and then started to weave in the opposite direction. This condition prevailed for the entire length of the run.

However, it must be noted that at no time in the entire length of the run did the wheel flanges remain in contact with the rail heads, but immediately reversed the direction of weaving. As previously mentioned, the weaving develops such a slight angle of the crane on the runway that it presents no problem whatever insofar as objectional operation is concerned.

There is, however, one slight difference when drivers are pushing the crane compared to the reverse action when they are pulling. In the case of taper tread wheels, there is greater tendency for the crane to center itself in much less time and distance on the runway when pulling than when pushing.

This condition prevails only when the crane has been either skewed or weaves on the runway, and it has no effect whatever on moving the crane when on absolute center.

The final demonstration was that of placing a heavy load, equivalent to the weight of the crane model, on one end of the crane. This was done to set up a condition somewhat similar to that of a crane cage with control at one end of a crane in the field.

The crane was then set on absolute centers of the taper tread wheels and operated from one end of the runway to the other and returned to its original position at the end of the track without moving even a fraction off its original center.

When skewing the crane or moving it over to one side with the flanges against the rail head, the same condition prevailed as was demonstrated without any additional load. This clearly brought out the point previously mentioned that, while outside forces may tend to change the course of travel, the crane will revert to the same weaving as was observed under normal operating conditions.

Reference is made to the article "Crane Wheel Tread Contours" published in Iron & Steel Engineer, October, 1952, by John Stolz. There are a few points brought out in this article to which the writer takes exception. The points referred to are comments by others and not Mr. Stolz's own opinion.

1. "Clearance between rail head and wheel flanges must be ¾ in. or 1 in. for straight treads, and 1½ in. for taper treads." No definite clearance can be set up, as allowable clearance must be governed by the ratio of wheel spread to bridge span. With long wheel base, the clearance can be greater than with short wheel base.

2. "Cranes equipped with taper tread wheels will weave on any runway, but they will not skew." This is not the case, the crane will definitely skew, which is the cause of the weaving. Only with the wheels on dead center will skewing or weaving be avoided.

3. Referring to the 3rd paragraph on page 105 of the same article, "Does change of taper speed up weaving or skewing"? As noted with the extreme taper illustration, as shown in Figures 13 and 14, weaving and skewing are reduced as the angle of taper is increased; however, heavy wear then becomes the problem and excessive angles of taper are therefore not recommended.

In conclusion, the following recommendations are made for the use of both taper and straight tread wheels:

Taper Tread—

1. For structures not too rigid; where a number of cranes are used on the runway, provided end clearances permit lateral float, and where small amount of weaving is not objectionable.

2. On long runways, not rigidly trussed, where straight treads would require running to one end of the runway to bring crane back into proper alignment by striking bumpers.

3. Where a series of runways are tied together, allowing lateral forces set up by adjacent cranes to affect other runways.

Straight Treads—

1. On structures considered quite rigid, properly trussed to prevent lateral movement. Particularly on single runways.

2. On short runways, with only one crane, where wheel changes would cost less than complete rail renewal.

This article has dealt only with the advantages or disadvantages pertaining to the use of taper and straight tread crane wheels and the writer has made no effort to present problems or conditions that might be the cause of crane wheel failures other than those directly attributed to types of wheel used.

No effort was made to deal with this problem from a metallurgical point of view, where the analysis of material and its treatment, in both the rail and wheels, does have some material effect upon the operating conditions in the field.

DISCUSSION

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R. J. Harry: Since the development of the double flanged taper tread track wheels for cranes, about 25 years ago, there has been considerable controversy as to the merits of this type of wheel. Many crane maintenance men have adopted the taper tread track wheel with most gratifying results. It is quite evident, however, that the use of taper tread track wheels is not a panacea for all operating conditions, as it has been found in some instances that the use of taper tread wheels has not effected a cure.

He has made a scale model of a crane, using all the various combinations of taper and straight tread track wheels in order to confirm the theory of the taper tread wheel. He has demonstrated very clearly that if the crane is square with reference to the runway, and if both driving wheels contact the rail on the same diameter of the taper track wheels, the crane will run square in both directions and will continue to do so.

He has also been able to demonstrate and confirm the original theory, that when the crane is out of square with the runway, it will weave as it travels up and down the runway with the minimum or no flange contact. This flange contact occurs intermittently when the skewing angle is great.

Mr. Bell has also been able to prove by his model, that the same course of action takes place whether the driving track wheels are pulling the crane or pushing the crane up and down the runway.

Mr. Bell has made the statement that if the runways were in perfect alignment and if the crane were properly designed, with the proper ratio of wheel base to span, and if the track wheels were all of the exact diameter, there would be no reason for installing taper tread track wheels on the crane.

In regard to this statement, I think there are some conditions which would prevent a crane from operating satisfactorily even though the provisions as set forth by Mr. Bell had been properly executed. We have encountered some conditions in the mills where one side of the crane runway would be directly over a mill using palm oil. The rails, of course, would become very, very slippery, and even though the crane and runway were in perfect condition and even with the correct ratio between the wheel base and span, the track wheels would slip on one side of the crane due to low coefficient of friction on the rails covered with palm oil. This would, of course, throw the crane into a skewed position on the runway, and if cylindrical wheels were used, the crane would continue to operate skewed on the runway, with resulting excessive wear of the flanges. We have this same situation in cases where heavy rainfalls would blow in on one side of the covered runway, making one rail slippery and the other, dry. We were able to obtain satisfactory operating results under both of the above operating conditions by the use of taper tread track wheels.

Also, in case there is only slight misalignment and the wheels are designed with good clearance between the rail head and the flange, in many cases this corrective action is obtained without flange contact. Flange contact is obtained only when the angle skew is great.

I am in perfect agreement with Mr. Bell's statement that if taper tread track wheels are used on the driver wheels, they should also be used on the follower wheels, as in this way the wear on the rail head will be uniform and the maximum contact obtained. This maximum contact reduces the unit pressure of the track wheel on the rail and will result in longer life of both.

Mr. Bell has stated that for heavy wheel loads the best combination is a cylindrical wheel on a flat head rail, but I would like to offer a suggestion which I think would produce equally satisfactory results, and that is—a taper tread track wheel on a taper head rail. In this way your unit pressures would be the same as for the flat head rail, and at the same time you would get corrective action in case the crane became skewed on the runway.

H. W. Ball: Mr. Bell is to be congratulated on the extremely thorough job he has done in preparing this paper and the experiments which include the model and the photographs showing the action of the various track wheels in contact with rail heads.

I have always been of the opinion that it was not necessary to use track wheels having tapered treads. To substantiate this statement there have been built several thousand cranes with wheels using rail head contour type tread. To the best of my knowledge there have been comparatively few complaints. The main objection was flaking of the tread. Invariably this was due to the high wheel load and possibly the hardness factor of the material used in the wheel.

Where the necessity exists for the use of a tapered tread track wheel, it has been my belief that the builder possibly used an improper ratio between the span of the bridge and the wheel base, or the crane runway was in such condition that it should have been repaired. Where these conditions exist, it is possible to improvise by using track wheels with tapered treads, but you affect parts of the crane equally important, such as end tie connections, pin connections, truck equalizer pins and the truck equalizing pin bushings.

From observation it has been noted that tapered tread track wheels are generally left operating on the crane long after the taper has disappeared due to wear, or the rail head has developed a taper which is comparable to that of the wheel. From this one would conclude that the necessity for the taper is questionable.

Again I should like to point out that standard rails have not been designed for eccentric type loading, which is one of the conditions created by a tapered tread

track wheel. When this practice is followed, however, the rail can develop cracks in the web under the rail head. To overcome this cracking, I should like to suggest that some investigation be made of the European type rails which appear to be superior in design to the rails furnished in the United States. The European rail is generally a low depth rail having an extra wide base and a web approximating the width of the rail head.

An example where an effort was made to overcome this eccentric loading on a United States type rail is that used at Hunters Point, based on specifications compiled by the Bureau of Yards and Docks. This application specified that the rails be set at right angles to the taper on the tread. This then allows the tread to have more contact on the rail head than under the conditions generally used in steel mill practice.

To me it does not follow within good design practice to apply the same wheel load to a rail head contour type tread having full line contact as to a tapered tread track wheel wherein you definitely have only point contact. I know of specific instances where this has created a condition where pieces of the tread separate from the wheel in chunk form.

In conclusion it is my opinion that there are many factors which contribute to skewing, such as improper gear ratios, severe plugging and acceleration, all of which are crane design problems that can be corrected in a manner other than the application of tapered tread track wheels.

Again I should like to state that I have the highest respect for Mr. Bell's findings and admit that his arguments are very sound; however, I believe that he has neglected to include the effect of weight, friction and efficiency in his model, which I believe are very influential factors.

J. J. Stolz: Mr. Bell certainly has spent considerable time and effort in bringing out several interesting points on the subject of crane wheels. As to the comments published in the October 1952, Iron & Steel Engineer, the crane builders have and do generally maintain that if the wheel base of the crane is sufficiently long in relation to the span, the crane will have less tendency to skew. If this is the case, then less clearance between the flanges and the rail heads can be used. I believe, speaking in generalities, $\frac{3}{4}$ to 1 in. clearance on straight tread wheels to be sufficient assuming that runways are kept in fair alignment. Here again maintenance of runways and equipment play a big part.

On taper wheels, $1\frac{1}{2}$ in. clearance over rail heads worked out fairly well throughout the years. If, however, runways are allowed to spread as much as 6 to 8 in., which we have actually seen, then almost any amount of clearance would be insufficient.

Cranes equipped with tapered-tread wheels will align themselves periodically due to the variation in gage of the crane runways. However, I agree that the tendency is to constantly weave. If by the use of taper treads flange wear is reduced to a minimum, then they are a worthwhile item to consider.

We have seen cases where wheels having a taper of 1 to 16 gave considerable trouble in rail breakage, rapid wear of rails, and heavy end thrust. By changing to 1 in 25 taper these troubles have been cured. On this point I believe much depends on the rail size and the general operating conditions. Certainly the smaller taper stresses the rail more nearly in the center of the ball and also causes less end thrust.

I would add a fourth category to the list of recommendations for the use of taper tread wheels, namely, that they should be used also on high speed cranes having long spans where the crane itself is not too rigid in construction. Long-span, light cranes are probably the worst offenders when it comes to skewing.

On the use of straight-tread wheels, I agree with Mr. Bell and Mr. Harry wholeheartedly that the rails should be produced with a flat head instead of the 12 or 14 in. radii as now being produced. With the increase of loads and speeds, more contact between rail and wheel is necessary as the wheels are being seriously overloaded constantly.

John L. Womack: Since we are talking about a comparison of "Taper vs Straight Tread Crane Track Wheels," I think it is important and proper to review some of the troubles encountered to give us the first tapered tread track wheel and a good background for this discussion.

About 1928, the Homestead works experienced so much trouble with track wheel and runway rails on three of our shipping cranes, at our old 110-in mill, it was necessary to find some solution to the excessive wear on the track wheel flanges and rail heads; also to the problem of shearing-off and breaking of rail clamp bolts of the J-type. I understood that on several occasions, one or two of these cranes actually jumped the track. We believe that the trouble referred to above was caused by misalignment of crane runway girders which threw the cranes out of line to a skewed position on the runway.

After experimenting with several unsuccessful schemes to remove the skew from these cranes, R. J. Harry (then assistant electrical superintendent, Homestead works), decided to try out his tapered thread driving track wheels and from that time to the present, no further track wheel or rail trouble has been experienced on these cranes.

The above experience and many other experimental installations of tapered tread driving track wheels with straight tread followers throughout our plant on cranes of 5 to 300-tons has convinced us, at Homestead, that the taper tread track wheel has solved about 99 per cent of our wheel and rail trouble. Since 1929, all of our cranes have been installed with taper tread drivers and straight tread followers.

The tapered (1 in 16) tread track wheel has not solved all of our trouble as we have four 300-ton, four-girder, ladle cranes where we have replaced many tapered and straight tread track wheels (on cab end only) due to inside flange wear. At the beginning, we believed that this wear was caused by the variation of the runway span from plus $\frac{1}{2}$ to minus $\frac{11}{16}$ in., so we increased the width of the treads from $5\frac{1}{2}$ to $6\frac{1}{2}$ in. without favorable result.

With further inspection of the above track wheels, we found that due to heavy wheel loads and untreated rails, the inside of the runway rail head on the cab end of the crane had mushroomed over about $\frac{3}{8}$ in. With this $\frac{3}{8}$ in. and runway span out $\frac{11}{16}$ in., we found that we had only $\frac{3}{16}$ in. instead of $\frac{3}{4}$ in. clearance between rail head and wheel flange.

In seeking a solution to the above ladle crane troubles, we have replaced (as of September 1954) the untreated runway rails with heat treated rails, and are now in the process of replacing the existing track wheels with a tapered tread of 1 in 25 instead of 1 in 16, so that the point of contact of rail head and track wheel tread will lie in the plane of the rail web to prevent mushrooming.

If runways are not out of alignment when erected, they soon will be, so why not prepare for the worst at the beginning and install taper treads on all new cranes. This is why I agree with the conclusions on the taper tread for drivers and followers.

In closing I wish to say that I am in accord with your findings resulting from your demonstrations under perfect conditions, and believe that all the results, except those of the first demonstration, could be applied to cranes on misaligned crane runways.

I would like to ask Mr. Bell a few questions:

1. You said that on your working model, wheels could be changed to obtain every conceivable operating condition and this should involve; (1) taper tread drivers with straight tread follower, (2) taper tread drivers with taper tread followers, but in your five demonstrations, nowhere have you given us the results of any taper tread drivers with straight tread followers. Why not?
2. Would you recommend tapered or straight tread track wheel for curved runways?

J. A. Bell: Mr. Harry refers to a condition where one runway rail might be slippery, causing the track wheels on one side to slip due to the low coefficient of friction. He also states that this would throw the crane into a skewed position on the runway, and if cylindrical wheels were used, the crane would continue to operate in a skewed position.

I would like to refer to the paragraph in which I make the following statement: "If crane runways were in perfect alignment, there would be absolutely no reason for installing taper tread wheels on any crane." "The reason for this is that clearances between rail head and wheel flanges could be reduced to a minimum and this would therefore eliminate any tendency to throw the crane out of line to a skewed position on the runway."

Therefore, even if the condition exists that Mr. Harry refers to, the minimum clearance would not permit the crane to get out of position any appreciable amount.

Mr. Harry's suggestion that for heavy wheel loads, the best combination would be a taper track wheel on a taper head rail.

I must take exception to this, as Figure 15 clearly demonstrates the condition prevailing with what we term standard taper of 1 in 16, yet there is a forward or reverse slippage of approximately $\frac{15}{16}$ in. for each revolution of a 30-in. wheel, which surely would be objectionable.

Also it must be remembered that the theory of a taper tread wheel functions as such only as long as the crown remains in the rail head.

Mr. Ball stresses the application of loads which differ with the type of wheel used. It certainly is not good design practice to apply any loads to a taper wheel with point contact on the rail that rightfully calls for a flat head rail with full width contact.

Mr. Ball recommends the use of wheels using rail head contour type tread. As shown in Figure 10 this type tread allows for no lateral misalignment of runway. It is rather difficult to imagine any crane runway of more than average width of span to be so perfectly aligned as to permit this type of wheel to function satisfactorily without maintenance.

Mr. Ball does admit that the main objection to this type wheel was the flaking of the tread.

It is this flaking that the writer takes exception to and can hardly be avoided since each increment across the face of the wheel has a different peripheral speed, causing slippage and resulting in the flashing referred to above.

I must agree with Mr. Ball in his statement that I have neglected to include the effect of weight, friction, and efficiency in the model, but as stated elsewhere in the paper, this could only be conclusively cleared up by erecting a test runway with a new crane in the field.

Mr. Stolz's point regarding change of taper from 1 in 16 to 1 in 25 is well taken. As he states, and as we have known for some time past, the taper given the wheel depends upon the size of rail used, for it is generally agreed that with less taper it becomes possible to bring the load more nearly to the center of the rail web.

In other words, the smaller the section of rail used, the less the taper should be on the wheel.

Mr. Womack's comments deal mostly with operating conditions in his plant where the use of taper tread wheels seems to be the general rule.

Mr. Womack questions why I have not shown the results of using taper tread drivers with straight tread followers. The only reason the results have not been covered in this paper is the fact that I am not recommending the use of straight tread idlers with taper driven drivers due to the resultant wear on the rail head developing an edge, as shown in Figure 8.

However, the tests definitely proved that the crane weaves and skews exactly the same as when using taper treads throughout.

Mr. Womack refers to the troubles they have experienced with the use of taper tread wheels on a 300-ton hot metal ladle crane.

The writer cannot conceive of these heavy loads being carried on anything but a flat head rail, and if flat head rails are used, surely the wheels should have straight treads, rather than taper.

Adding to the width of a taper tread wheel will not help matters. As mentioned previously, taper tread wheels function best when used with crowned head rails. It is possible that the trouble Mr. Womack refers to is caused by the rails having only a very slight crown, and the taper wheel bearing too far off the web center of rail, which induces mushrooming.

Mr. Womack asks a second question, "Would you recommend tapered or straight tread track wheels for curved runways?" It has always been our practice to make every effort to keep runways in true alignment rather than complicate matters by resorting to curves.

However, the theory of the taper tread might be better explained by reference to railroad wheels, which are coned, with its greater diameter nearer the inside flanges, in order that the outer wheels, (traveling always toward the outer rail) may thus be made to roll upon their larger diameters and the inner wheels upon their smaller diameters.

By JOHN A. TOTH, Assistant General Manager, The Torrington Co., Bantam Bearings Div., South Bend, Ind.

Bearing Maintenance for Economy

. . . . good bearing design and careful maintenance will result in lower steel-making costs . . . .

▲ THE iron and steel industry in the United States promoted capitalized expenditures for new plant and equipment during the period between 1945 and 1951 in the amount of $4,607,000,000. In 1930 there were seven four-high continuous hot strip-sheet mills in the United States and by 1951 the number increased to 29. Relative increased capacity was necessary for furnaces, cold mills, pipe and tube mills, structural mills, electrolytic tinning and continuous galvanizing equipment.

The progress of increased productivity is revealed from statistical data on men, animals, and machines. In the year 1900, production was accomplished by using 10 per cent manpower, 52 per cent animal power, and 38 per cent machines. Comparative estimates show that in 1960 manpower will be at 3 per cent, animal power at 1 per cent, and machinery increased to 96 per cent.

Many anti-friction bearing applications were made for the expanded facilities and the attention to bearing maintenance became a vital factor for economy and efficient continuous operation. Economy applied to bearing maintenance in steel mill operations definitely is related to unit cost of the product. The competitive situation for quality products at minimum cost, which has developed since the last emergency periods, can certainly be improved with maximum tonnage and service life from bearings.

The multimillion dollar investment in hot and cold strip mills, or auxiliary equipment, only pays dividends with continuous operation and minimum down time. Reduced bearing cost can be gained by having every bearing assembly operate to maximum service life.

Roll neck and auxiliary equipment bearings will provide this service when correct application and maintenance is performed under proper supervision with adequate facilities and tools.

Anti-friction bearings are manufactured today under very rigid engineering specifications. Improved design proportions, bearing quality materials, and better manufacturing methods — including advanced metallurgy — are giving improved performance records. This progress by the bearing manufacturer is of no value unless proper application, lubrication, and maintenance are exercised in a carefully planned manner.

The value of bearings will vary from less than one dollar up to a figure of approximately $16,000 per bearing. Based on the hundreds of bearings used in steel mill equipment, a monthly expenditure for roll neck bearings alone can range from $1000 up to $30,000 or more.

Experience and recorded data, unfortunately, prove that the lack of sufficient spare bearings increases cost and reduce the desired service life of the bearings. The majority of bearing applications operate too long before they are given a maintenance check. Roll neck bearings represent the most critical situation because of the turnover for replacements. A lack of roll neck bearing spares will not permit regular inspection and adjustment for the bearing assembly. Adequate spare bearings and chocks must be made available to allow for inspection, necessary adjustment, and rework at maximum six-month intervals; however, under severe operating conditions, a three or four-month cycle should be considered because of seal or lubricant breakdown plus abnormal service experience.

We stress frequent inspection because the outer races of the bearings are loaded through an arc of approximately 72 to 90 degrees. This load zone area is therefore stressed for approximately 25 per cent of the total raceway. At each of the four inspections, the outer races can be rotated 90 degrees to a complete new load zone area with resulting increased service life. Under pure thrust load conditions, the total individual raceway areas are used initially and multiple row bearings can be turned to alternate ends for load distribution.

Two roll neck bearings are used on each roll with one bearing acting as a thrust assembly to locate the roll axially. The other bearing is used as a floating assembly to allow for axial displacement when expansion, contraction, or adjustment for accumulated tolerance is necessary. The floating assembly is not subjected to the combined radial and thrust loads because the self-contained assembly will only position the chock or

housing in the mill. Therefore, it is considered good practice to interchange bearings from thrust to floating positions to gain maximum service life.

The contributing factors for reduced bearing service life expectancy are:

1. Faulty handling and application at assembly.
2. Incorrect lubrication by volume and type of lubricant.
3. Misalignment due to foundation settlement, housing or frame distortion and warpage, inadequate structure strength, excessive wear of guide plates and improper installation.
4. Differential heat expansion within the bearing mounting.
5. Abnormal loading caused by excessive overload, wrecks, cobbles, and bent or broken rolls and shafts.
6. Improper shaft and housing fits which affect the radial clearance of the bearing assembly.
7. Excessive speeds without proper clearance adjustments and lubrication.
8. Contamination such as dirt, scale, water, and coolants.
9. Lack of preventive maintenance at regular intervals.
10. Improper bearing type for the condition of loads and speeds.

In many cases the extent of damage to bearing elements because of abuse or mishandling cannot be evaluated. The familiar practice of heavy impact loads from a sledge hammer or roll changing rig will cause brinelling or permanent deformation between the contact surfaces of the rollers and races. These highly stressed areas may iron out after the bearing is rotated, but a condition of spalling and flaking can be expected from the increased localized stress pattern.

A condition of corrosion from etching and pitting will also reduce the basic bearing capacity and expected service life. In a ball bearing assembly, the contact between the balls and races is limited to point contact or an oval area contact as the load is increased. The roller bearing will provide a line contact between the rollers and races so that a rectangular area develops as the load increases. These areas of contact are measurable projected areas which can be loaded to a unit pressure ranging from 400,000 psi to 625,000 psi. Any loss of the projected area of contact because of corrosion and pitting will reduce the bearing capacity and also cause the bearing to become rough and noisy.

Bearing assembly in chocks and housings becomes particularly critical with tapered roller bearing mountings. Correct endwise clamping through the outer or inner races will properly position the spacer rings for the control of diametrical clearance. Improper end clamping of tapered roller bearing races will allow excessive axial movement of shaft or roll and reduce the contact load zone area in the bearing. The ratio of axial movement to radial clearance in tapered roller and spherical roller bearings is approximately 4 to 1, and this will vary depending upon the bearing angle. Maximum thrust capacity is available with steep angle bearings such as used on work rolls. Shallow angles at approximately 10 to 12 degrees are used for back-up roll neck applications with resulting maximum radial capacity to take care of screw down pressures.

The accuracy of mill housing liner plates is very important to maintain alignment for rolls. This prevents the condition of cross-rolling which results in excessive thrust loading. The tongue and groove clamping arrangement for roll neck bearing chocks at the thrust end position must be controlled to engineering specifications. This is recommended so that the roll crowns will match for uniformity of gage when rolling.

Bearing selection by type and size can be engineered by mathematical analysis and also experience data accumulated from laboratory tests and actual service applications.

The life expectancy theory for anti-friction bearings of all types is very similar to the statistical records of the insurance companies where human life averages are established in determining premium values in dollars and cents. The monetary premium value is proportioned to the amount of life insurance protection carried by individuals. This thought is directly related to the fact that the dollar value for anti-friction bearings in steel mills must assure satisfactory service on an average life basis so that the cost is within reasonable figures.

To make a life prediction for anti-friction bearings it is necessary to evaluate the conditions of operation in terms of their effect upon the bearings. Some factors which enter into this problem are: load, speed, conditions of smooth or shock operation, corrosion influences, accuracy of members adjacent to the bearing, temperature, and lubrication. These factors may be easily formulated in many cases while others present greater difficulties. Frequently the presence of errors in assessing these values causes considerable disagreement between the computed and actual life of a bearing installation. It is at this stage that experience and proper engineering analysis is mandatory for correct selection of bearing types and sizes.

It is possible to predict, with surprising accuracy, the average life of a group of bearings. This permits the application of the law of averages. Obviously, the larger the group, the more accurate will be the prediction. Statistical data taken from actual laboratory tests, as well as service experience, indicates that an approximate 10 per cent of the bearings in a group are not predictable for life expectancy.

The understanding of the bearing life expectancy theory should intensify the need for proper maintenance and minimum bearing replacement cost. Many papers and articles have been published to cover methods and procedures for bearing application and preventive maintenance. A review of such available reference is recommended and all bearing manufacturers are willing to cooperate for detail data as required.

As past chairman of the Roller Bearing Engineers' Committee of the Anti-Friction Bearing Manufacturers Association, the writer is pleased to report that considerable progress has been made toward standardization of a basic method for calculating bearing capacities. Completion of this project within the near future will permit standardization of bearing types and sizes for interchangeability in the industry.

Standardization of bearing types and sizes by the mill builders has already allowed for economies, but further progress along these lines is highly recommended on the basis of common bearing usage rather than

special sizes with very minor deviations from published bearing catalogs.

It is evident that the first phase of bearing application analysis must be developed by detail engineering study so that preventive maintenance can be carried out efficiently and effectively. Better understanding of bearing applications can be achieved when the operating personnel or maintenance men are encouraged to study them. The efficiency of maintenance procedure will exist only by careful planning and training of personnel. A complete print or card record system is necessary on all bearing applications. A schedule of periodic checks and procedures related to engineering specifications from the plant or bearing manufacturer is valuable. Vital bearing applications should be recorded in a manner similar to the automotive service manuals where motor oil changes, transmission, differential, and wheel bearing check recommendations are listed for attention at specified mileage or service periods.

The bearing maintenance room should be clean and properly equipped with facilities and tools to handle all types and sizes of bearings used in the plant. The following equipment is recommended for the bearing maintenance shop:

1. Overhead crane capacity for lifting bearing parts and assemblies.
2. Cleaning tanks and cleaning pit area.
3. Work benches.
4. Fixtures for handling bearing parts and assemblies.
5. Floor press and fixtures for bearing removal from housings and shafts.
6. Test fixture for bearing spacer check and adjustment.
7. Storage facilities for seals, gaskets, wrenches, micrometers, sliding parallels and feeler gages.
8. Compressed air for powering air wrenches and portable grinders.
9. Lubricating equipment for initial lubrication of bearing assemblies.
10. Oil heating tank for bearing assembly to shafts having interference fits.
11. Office space for bearing service and application record file.

Radial clearance for bearing assemblies will depend entirely upon the type of bearing used and service requirements. Roll neck bearings with a loose fit for shaft and housing will have a radial clearance adjustment entirely different from the conventional mounting where interference fits are applicable at the shaft or housing. Temperature and speed will also introduce special requirements for radial clearance. Self-contained bearing assemblies such as the ball radial type, self-aligning spherical roller type, and nonseparable cylindrical roller bearings, are not adjustable after assembly in the bearing plant. However, tapered roller bearings are adjustable through spacer size variation, and such practice should follow specific engineering recommendations. It is safe to consider radial clearances on the loose side of the tolerance rather than the tight side because of the tendency for negative tolerance accumulation, for resulting tighter fits on new equipment and the possible slight distortion or out-of-round condition in used equipment. Precision bearing applications for machine tools and slitters have very accurate concentricity tolerances because of minimum radial clearance specifications.

The following data of Table I will serve as a general guide for permissible maximum oversize and out-of-round condition for roll neck bearing chocks with tapered roller bearing mounting.

TABLE I

Bearing outside diam, in.	Normal fit (loose) in.	Maximum out-of-round, in.	Maximum oversize, in.
Up to 12	0.001-0.003	0.006	0.009
12-24	0.002-0.006	0.012	0.018
24-36	0.003-0.009	0.018	0.027
36-48	0.004-0.012	0.024	0.036
48-60	0.005-0.015	0.030	0.048

The maximum looseness between bearing bore and roll neck is given as a general guide in Table II.

TABLE II

Bearing bore, in.	Normal fit (loose), in.	Maximum looseness or regrinding limit, in.
4- 5	0.004-0.006	0.018
5- 6	0.005-0.007	0.021
6- 8	0.006-0.008	0.024
8-12	0.007-0.009	0.027
12-24	0.008-0.012	0.036
24-36	0.010-0.016	0.048

Correct sizes, fits, and tolerances for all other types of bearings in auxiliary equipment can be found in detail in respective catalogs of the bearing manufacturer.

The next vital consideration believed to be recognized by plant management, as an important factor for economy of operation, is lubrication. Lubricant manufacturers and bearing manufacturers have recognized the value of good lubrication practice and trained personnel to achieve substantial reduction in bearing maintenance costs. Experience has proven the economy of good lubrication practice by reducing work orders almost 90 per cent.

The bearing manufacturers are primarily concerned with engineering and production of bearing elements for assemblies to meet conditions of operation. The numerous lubricant manufacturers in the country have extensive research programs which make it impractical for the bearing manufacturer or user to maintain progress reports on developments; therefore, recommendations cannot be made without some reservation for each and every bearing application. However, because of the fine cooperative effort between bearing and lubricant manufacturers and the user, specifications are available on lubricants which will permit fairly accurate and satisfactory recommendations. It is not desirable to use more than one type of lubricant for any one bearing mounting, because of the question of compatibility of mixed lubricants.

The lack of volume control during lubrication of anti-friction bearings becomes critical because excess volume will cause a temperature rise and breakdown of the lubricant. Minimum volume does not provide

sufficient lubrication to prevent metal-to-metal contact of bearing elements and gear teeth.

Considerable discussion and difference of opinion has developed on the types of lubricants which will protect bearing elements against premature fatigue failures. It is generally accepted that heavy consistency lubricants are not satisfactory for good bearing lubrication. The lack of fluidity and the condition of channeling will not allow lubrication of the bearing contact surfaces. For example, roll neck bearings are loose fitted in the bore to allow for frequent roll changes. Lubrication between the bearing bore and the roll neck is absolutely necessary to prevent galling and scoring of these surfaces. The normal roll neck bearing mounting has the fillet spacer and end clamping ring made with alternate grooves and hard facing at the surface contacting the bearing inner race. It is through these grooves and those in the bearing spacer rings that lubricant is applied to the bearing bore. It is therefore recommended that radius grooves be machined in the parts for maximum cavity area for lubricant flow. The heavy consistency lubricant cannot flow freely if the grooves are too small.

Experience with high-tensile bronze facing rings for fillet spacers and end clamping rings has satisfactorily reduced wear and increased cavity area for good roll neck and bearing bore lubrication. Experimental service applications are also being conducted on the use of high-tensile bronze for cone spacer rings.

Mill operators are conducting numerous tests on the application of oil lubrication by using circulating system and the recently developed oil-mist type lubrication system. Actual test results with oil-mist lubrication systems on machine tool spindles and other miscellaneous applications has proven very beneficial. Service life ranges from three to six times greater than with previous methods of sight feed lubrication. The primary reason for increased life with circulating oil lubrication or oil-mist type system is the elimination of contamination of bearing contact surfaces. This is evident by the lack of denting on the surfaces of the rollers and races when they are inspected.

The problem of sealing against oil lubricant loss is not critical. The convenience of volume control, typical in the oil-mist system, assures satisfactory bearing lubrication. Proper design for adequate sealing and protection against contaminants can be accomplished. The oil-mist system does not require a complicated sealing arrangement because the application of air pressure provides an air seal at the ends of the bearings. Work roll and back-up roll bearings have been lubricated successfully with an oil-mist system as well as with circulating oil lubrication.

There is no question about the benefits of oil lubrication. Make-up oil can be easily added if a circulating system is not used so that bearing elements are clean and the condition of oxidized lubricants is eliminated. A grease lubricated bearing assembly requires attention for the proper condition of the grease during operation. It is not practical to try to flush out old grease which may break down due to molecular friction or contamination. Complete disassembly of housing and bearing is required to assure thorough cleaning of bearing elements and housing cavities. This involves delay for higher maintenance cost and increased work order schedule.

In addition to proper lubrication, the application of seals and maintenance for elimination of contaminants in bearing mountings is very important. There are many types of seals and sealing arrangements for all applications. Briefly, contact seals require good smooth surfaces at contact areas. Contact seals should be applied to allow lubrication of sealing surfaces. This can be done by positioning seals in a mounting to permit lubrication from bearing housing cavities, or by using in pairs with a separate fitting for their lubrication independent of the bearing. Various types of labyrinth seals are used where condition of contamination is not critical or where high speed operation and excessive temperatures occur.

An effort was made to develop statistical data on annual operating costs for bearings based on strip mill operations and replacements. However, the study at various plants indicated tremendous variations because of the cost allocation methods used. The analysis proved the value of proper engineering, adequate bearing inventories, standardization, and proper preventive bearing maintenance procedures.

Engineering improvements at one mill operation have increased average bearing service life more than five times and reduced cost per ton of steel rolled. Trained personnel, proper procedures with adequate facilities to handle bearing maintenance were made an important part of this program.

Another mill operation which revised the method of lubrication as a major change, reduced bearing replacement cost 35 to 50 per cent over the past 10 to 12 years. The specific change was the use of oil lubrication for roll neck bearings instead of grease. Experience during this period on reversing and tandem cold mill operation has also verified that work roll bearings can be lubricated with a soluble oil mixture. The basic product is a light soluble pure oil at about 80 viscosity — mixed to a ratio of one part soluble oil to ten parts water. This product is also used as coolant on the strip and no serious condition of corrosion has developed in the bearings or on the strip.

The use of soluble oil spray on work roll drive shaft coupling universal joints has increased life of the joint eight to 10 times greater than with grease lubrication. These results are based on the fact that grease in universal joints has a tendency to escape because of centrifugal force. Also, the frequency of high pressure gun lubrication is limited, because of continuous operation when metal-to-metal contact can develop.

Comparative cost analysis on the use of grease as a lubricant and oils will be quite revealing for economy. In addition, good housekeeping around the mill and roll shop will become an easy task with oil lubricants.

A point of clarification on bearing repair is presented for complete understanding of possible hazards. Many bearing elements are processed from case-hardening bearing quality steels rather than the conventional high-carbon and high-chrome or through-hardening bearing steels. A carburized bearing part is heat treated to have sufficient case depth proportionate to the cross section. With limitations on thin section parts, regrinding can remove much of the case depth so that the load carrying capacity of the bearing element is substantially reduced. In through-hardened bearing elements, regrinding will reduce surface hardness and relatively

affect bearing capacity. It is therefore recommended that careful analysis be made of the bearing and its application prior to repair authorization. Repair procedure by the original bearing manufacturer will guarantee proper evaluation of future service life depending entirely upon the extent of surface material removal by regrinding or other type of rework. Proper tools for accuracy in checking sizes and magnaflux inspection of surface condition in bearing elements will eliminate premature failure and downtime for replacement of repaired bearings.

Bearing applications for steel mill operations are not limited to roll necks or auxiliary equipment alone. Many secondary units which fit into line production become a vital factor for continuous service. For example, the first phase of productive equipment processing must be related to secondary units from the standpoint of uniformity of life factors for the bearings. Downtime on either unit will affect the other. Therefore, it is evident that engineering details and bearing applications be carefully analyzed to allow for uniformity of service life expectancy from the bearings in related production equipment. A low cost or inadequate bearing mounting can contribute to downtime periods and unnecessary delay in production which results in abnormal loss considerably in excess of the dollar value of the bearing selection.

The general trend for increased burden costs plus all other operating costs which expand with increased capacity and facilities, can only be controlled by operating each and every item of productive equipment at full capacity. Reduced operations, which prevail at the present time, will add to burden cost figures so that efficiency of operations becomes more important with bearing service as a contributing factor.

The past 12 to 14 years through the emergency periods have limited preventive maintenance on facilities, and it is felt that management and engineering encourage review of bearing maintenance procedures for economy benefits.

The subject of this presentation is broad and does not cover details which will reveal specific recommendation to fit each and every facility; however, important factors which are applicable and of interest individually can be investigated by direct contact with the bearing manufacturer, mill builder, lubrication engineer and the seal source.

There can be no question about the economic gain with good bearing performance and a planned program of maintenance procedure.

DISCUSSION

PRESENTED BY

S. M. WECKSTEIN, Chief Engineer, Industrial Division, Timken Roller Bearing Co., Canton, Ohio

JOHN P. CRITCHLOW, Product Application Engineer, Gulf Oil Corp., Pittsburgh, Pa.

JOHN A. TOTH, Assistant General Manager, The Torrington Co., Bantam Bearings Div., South Bend, Ind.

S. M. Weckstein: We agree that a well balanced and properly executed maintenance program will pay large dividends in increased bearing life. Frequency of inspection, readjustment and reworking of bearings is a problem which must be worked out in each individual mill. It depends upon the type of mill and operation. In some cases, a three or four month cycle is necessary. In other cases, a nine-month to 12-month cycle is satisfactory. Regardless of the cycle established, we concur in the advisability of rotating the outer rates of the bearings through an arc of 90 deg at each inspection period. In the case of continuous mills, it is important that the bearings be moved around from the low speed to the high speed stands and back again, in order to distribute the load on the bearings. We also recommend moving the bearings around from top to bottom rolls and from the fixed end to the floating end of the roll.

On the subject of bearing capacity and pressure in the contact areas, the figures which are given as ranging from 400,000 to 625,000 psi must refer to ball bearings. In our bearings we are working with pressures in the range to 140,000 to 175,000 psi.

Mr. Toth states that bearing assembly in chocks and housings becomes particularly critical with tapered roller bearings. I believe that he is referring to the two or four-row bearings which are supplied with cup and, or, cone spacers for the setting of the bench or unmounted end play in the bearings. It is important that such factory preadjusted bearings be mounted on the journals and in the housings with the recommended fits in order to obtain the desired operating looseness in the bearings. In the case of the standard four-row tapered roller bearing, the outer races and cup spacers should be clamped in the chocks through a compressible gasket. The inner races should not be clamped tight on the roll neck. The roll neck retaining device, whether threaded nut or specially designed filler ring, should be brought up until the bearing is clamped against a solid seat and then backed off an amount recommended for the particular bearing size. Clamping the bearing on the neck will generate heat and excessive scuffing of necks, cone bores and filler rings.

So there will not be any misunderstanding about the angles used in tapered roller bearings I wish to clarify Mr. Toth's statement. The figures which he gives are for one half the included cup angle. In other words, the included angle of the cup, or outer race, is from 20 deg to 24 deg. In designing backup roll bearings, we try not to use included cup angles below 24 deg.

The subject of bearing lubrication is very important. We feel that there is a definite place for grease, circulating oil and mist lubrication systems. Each system has advantages and disadvantages. With very few exceptions, on existing mills, grease has been quite satisfactory. With the advent of higher speed mills, it has been necessary to recommend circulating oil lubrication. We can give you an idea of the amount of oil required for each bearing on a specific job. It is up to the mill builder and the operator to consult with the oil suppliers on the tanks, pumps, filters, and controls required to make such a system efficient and reliable.

Some mill operators have recently installed mist lubrication systems and we are advised that these systems are doing an excellent job. We regret to go on record that we have not had exact information on the design of these systems and consequently at present are not

in position to make recommendations on the mist system. We urge that builders and operators work direct with the manufacturers of the mist systems and have them engineer each installation. We also again wish to emphasize the fact that backup roll bearings of the tapered roller design require a high grade extreme pressure lubricant. This also applies to mist systems where extreme pressure oils should be used.

John P. Critchlow: This excellent paper contained several practical recommendations which I am sure, if followed, could account for considerable savings in bearings and a great reduction in maintenance costs.

There are two points that particularly interested me. One was a card system or some other system for keeping a record of bearings and bearing life. That in itself will not reduce maintenance costs, but psychologically it emphasizes a problem in any mill and tends to pinpoint attention on bearings. From a practical point of view, I think a lot of people would be amazed if they knew the complete history of the bearings in their mills.

A good record system will provide a plan for bearing change and replacement. For instance, a complete record can be kept of roll neck bearings by tabulating their history, i.e. when installed, when turned, when moved to a new position on roll neck, when moved to another mill stand, when failed and for what reason. Such a history for several bearings can not only pinpoint weak spots in a mill, where bearing life is continually low, but can reduce bearing costs by making maintenance people bearing conscious.

Another point was the mention of a circulating oil system for roll neck bearings. I do not believe there are too many mills using circulating oil on work roll or back-up roll bearings. In general, oil will provide better lubrication than grease. Grease, however, has many advantages, particularly on roll necks. It acts as a seal and requires very little attention. The atmosphere around most mills is such that bearings have to be protected, so both circulating oil and grease have their place. I do think, however, that there are a lot of mills currently using grease that could operate a lot more efficiently with a circulating oil system for their roll neck bearings.

I would like to ask Mr. Toth if his company has had much experience with circulating oil systems, particularly on work roll bearings on four-high stands.

John A. Toth: Actually, the experience we have had with bearings on mills with oil lubrication is limited. As Mr. Critchlow mentions, there are very few applications today, but at the same time we would like to point out that there are many bearing installations that have been changed over from grease to oil in our own shop, and in many other types of applications, where we know specifically that the bearing life has been increased tremendously. This is primarily due to the fact that oil lubrication does have a tendency to minimize or completely eliminate contaminance, even though grease is used in many roll neck bearing installations as an additional seal to protect the bearing.

We feel that there is very limited attention given to seal maintenance for back-up and work roll bearing chocks, and this factor alone will introduce an objection to the use of oil lubrication, because the lack of proper seal maintenance will result in loss of fluid lubricants to a greater degree than that which would be experienced with the heavier consistency grease.

Mr. H. Fisher of the Acme Steel Co. has been operating his cold mills with old lubrication and it was specifically mentioned in the paper that in the past 10 or 12 years there has been a 35 to 50 per cent bearing cost reduction, which has been revealed from the records at this operation.

The application of oil lubrication to roll neck bearings cannot be set up for laboratory test or check, but it is gratifying to see that some of the mills around the country are using oil mist lubrication, and at the same time seriously considering the use of oil lubrication. Preliminary reports to date indicate that the results have been satisfactory.

The figures given in the paper for bearing capacity and pressures in the contact areas at 400,000 to 625,000 psi represent the maximum pressures for the condition of ultimate loading. We are in complete agreement that the working pressure in the range of 140,000 to 175,000 psi is necessary to maintain satisfactory service life results. The details given in the paper on life expectancy will clarify the reduction of bearing life based on condition of overload, and it is for this reason that we emphasize the importance of proper engineering analysis and consideration for all bearing applications to meet the conditions of operation and the required service life expectancy.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

the modern Continuous Weld Pipe Mill

By L. V. JOHNSON
Chief Engineer
National Tube Div.
United States Steel Corp.
Pittsburgh, Pa.

. . . . because of stretch reducing, a wide range of sizes can be produced from only four widths of skelp . . . .

▲ IN 1825 the first butt weld pipe was made by drawing white-hot metal strip through a forming die. Since that time, the efforts of pipe makers to develop improved methods of manufacture have been unceasing. The success of the joint efforts of operating companies and machinery manufacturers in this never ending search for a better way has been recorded from time to time in papers presented before the AISE.

The evolutionary trend in the manufacture of continuous butt weld pipe has been continued at the Fairless Works of National Tube Division, United States Steel Corp., for here, the maximum application of the stretch reduction principle permits the production of the full range of pipe sizes from a relatively few skelp widths.

The plant is designed to produce 281,000 tons per year of ½ to 4 in. butt weld pipe from slabs 3½ to 4 in. thick, 7 to 16 in. wide and 40 ft long, which are obtained from the rolling mills of United States Steel Corp., central operations, Fairless Works, located adjacent to National Tube Division site. The facilities to convert these slabs to finished pipe consist of one 10-stand continuous skelp mill, two continuous butt weld pipe mills, a galvanizing department, finishing equipment for facing, threading, testing and coating, and a warehouse for stocking and shipping. In addition to the production units, the plant has complete auxiliary facilities such as maintenance shops, heating plant, storeroom, fuel oil storage, etc.

This plant as designed provides for efficient material handling by either railroad or truck of all incoming and outgoing materials. In moving steel in process through the various departments, self-propelled mobile equipment, such as fork trucks, side loaders, and straddle trucks have been used extensively to provide more efficient and flexible material handling. Practically all units in the plant are accessible by mobile trucks. Total mill building area under roof is approximately 880,000 sq. ft.

SLAB HANDLING AND SLAB HEATING

Slabs are delivered to an open slab storage yard in standard gage slab cars. The slab storage yard provides 28,000 sq ft of usable storage area holding at maximum approximately 75,000 tons of slabs. Ample room is provided for segregation of various sizes to give immediate slab delivery upon mill demand, and for inspection. The area is served by one 30-ton electric overhead traveling crane with a turnaround trolley. A turnaround trolley was incorporated on this crane to permit maximum utilization of the storage area by stacking successive slab tiers at right angles to each other to obtain a more stable stack. Should requirements dictate, it will be possible to tier the slabs into

Figure 1 — Slab heating furnace at Fairless has a maximum rated capacity of 120 net tons per hr.

15-ft high piles. Two 15-ton, rectangular magnets, spaced 13 ft 6 in. on centers, are used in handling the slabs.

Located at the north end of the slab storage yard and under the storage yard crane are the slab separating skids and the furnace charging conveyor. For feeding the furnace, the slab separating skids consist of both stationary and movable skids which are arranged to provide a cascade effect which separates and aligns individual slabs, and deposits them singly onto the furnace charging conveyor. These skids insure proper feeding of the slabs onto the charging conveyor and eliminate all manual separation of the slab lifts. The furnace charging conveyor, approximately 110 ft long, conveys the slabs from the separating skids to the furnace.

Slabs deposited on the charging conveyor are pushed into the slab heating furnace by means of a track-mounted charging ram. This ram is equipped with a control permitting automatic positioning of varying length slabs in the furnace so that the leading end of the slabs are always aligned. Ahead of the charging conveyor, a slab turnover and reject mechanism is furnished to reject defective slabs and to turn up sheared ends which might otherwise damage the furnace bottom.

The slab heating furnace shown in Figure 1 is of the side-charged and side-discharged, zone-controlled, double-fired type. The effective heating surface of the furnace is 60 ft in length and 40 ft in width. It has a maximum rated capacity of 120 net tons per hour. The furnace has top firing in both the primary and secondary heating zones, but the design is such that should future requirements warrant, bottom firing may be added with considerable increase in furnace capacity. The furnace may be coke oven gas or oil-fired. The combustion air is preheated in a refractory tile recuperator located beneath the furnace.

Located on the charging end of the furnace is the slab cross pusher for advancing the slabs through the furnace.

SKELP MILL

The skelp mill, shown on Figure 2, is a close coupled hot strip mill having ten individually driven horizontal stands and five edging stands.

All horizontal rolls are carried by oil film-type sleeve bearings. The top rolls and their bearings are hydraulically balanced. The bottom roll neck bearings on the working side of each mill are located axially by means of a parallelogram adjusting device which eliminates the necessity of any bearing clamps on the drive side and makes for readily accessible adjustments from the operating side. The bottom rolls are adjusted by means of a screw and wedges accessible from the operating side of the mill. The last five horizontal roll stands are equipped with motor-driven screwdowns so arranged that the top screws may be adjusted in parallel or individually.

The pinion stands for each horizontal mill stand have fully enclosed heavy semi-steel constructed housings. Each pinion is of the double helical-type with hobbed teeth which are case hardened.

All five edging mill housings are of heavy cast steel construction with all gears and bearings fully enclosed. The first edging mill ahead of No. 1 horizontal stand is a standard 16-in. type. The second edger ahead of horizontal stand No. 4 and the third edger ahead of horizontal stand No. 6 are of the standard 12-in. type. The fourth edger ahead of horizontal stand No. 8 and the fifth edger ahead of horizontal stand No. 10, due to their light service requirements and to facilitate roll changing, are of the 12-in. overhung type.

All horizontal roll stands, as well as all five edging mills, are driven by separate adjustable speed motors. The connected load of the main drives totals 8400 hp which comes from two 3000-kw, 600-volt mercury arc rectifiers of the sealed tube, pumpless type.

Descaling is performed by means of 1000-psi water pressure to banks of top and bottom sprays located before each of the first three mill stands.

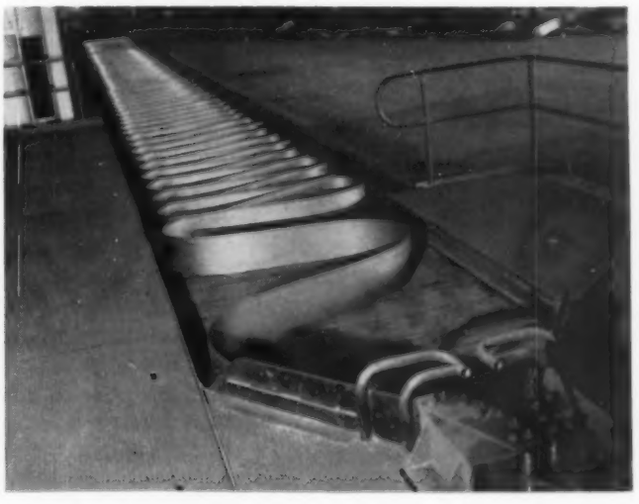
Delivery speeds to the runout table vary between 377 and 1381 fpm.

Referring to Figure 3, the strip rolled on the skelp mill for subsequent coiling is turned on edge and delivered alternately to two parallel apron-type conveyors which convey the strip to the coilers in the proper position for coiling on edge.

Polished cast iron twist troughs are provided to turn the skelp on edge. In conjunction with the twist troughs are a horizontal pinch roll unit, a vertical pinch roll unit

Figure 2 — The skelp mill is essentially a close coupled hot strip mill.

Figure 3 — Skelp is turned on edge for coiling.



and a strip switch. The strip switch, which is automatically operated by a photo-electric control system, is a mechanical guide trough which is swiveled about its entry end, while its delivery end is free to move to direct the skelp alternately to either of the two vibrators which feed the skelp in serpentine form onto the apron-type conveyor. From the strip switch through to the unloading of the coils into storage, dual facilities have been provided to handle the mill output.

Skelp from the mill outlet conveyor is fed directly onto the apron-type conveyor at a speed of from 54 to 162 fpm. This conveyor, which provides storage for approximately 1600 ft of skelp, holds the skelp while the leading edge is trimmed square and manually fed into the reels for coiling. The trimming shears are of the vertical alligator-type and have a capacity for shearing skelp up to 18 in. wide.

Two vertical-type skelp reels are provided for receiving the skelp delivered from the apron-type conveyors. The reel centers are of the collapsible type and upon completion of a coil are automatically collapsed and withdrawn below the surface of the coil. The centers are designed to form coils having an inside diameter of 20 in. Each reel is provided with a coil pushoff which has a maximum speed of 8 strokes per minute for pushing the coils onto the coil conveyors.

The coil conveyors are of the double roller chain type with the coils riding on the chains on six-ft centers. The conveyors are approximately 90 ft long and have a maximum speed of 15.5 fpm. In conjunction with each conveyor, scales are provided for weighing coils.

Removal of coils from the assembly conveyors to the coiled skelp storage area is normally by an electric overhead traveling crane equipped with a "C" hook, and turnaround trolley, but an optional means in case of crane failure is provided by a 15-ton ram truck.

The coiled skelp storage building is 416 ft long and 94 ft, 9 in. wide. Located within this building are parts of the two apron conveyors, the two coilers, the two coil conveyors, two coil up-enders and assembly conveyors and one transfer car for transferring the stored coils as required to the pipe mills.

Coils are stored upright, inasmuch as that is the position required for the uncoilers and flash welders at the pipe mills. The permit storage in this fashion, "leaning posts" are provided. Coils are moved from storage by crane or ram truck and loaded on the transfer car for delivery to the uncoilers at the pipe mills.

WELD MILLS

The pipe making facilities consist of two complete continuous butt weld pipe mills of the latest design. The No. 1 mill converts coiled skelp into ½ to 1½-in. pipe at speeds varying from 1250 fpm for ½-in. pipe to 528 fpm for 1½-in. pipe. The No. 2 mill converts coiled skelp into 1¼ to 4-in. pipe at speeds varying from 650 fpm for 1¼-in. pipe to 229 fpm for 4-in. pipe. These mills, shown in Figure 4, depart considerably from any existing continuous weld mills in obtaining greater production through the use of wider skelp and high mill delivery speeds. This, to a large degree, is made possible by employing the stretch-reducing principle in pipe making, which necessitates the usage of only four widths of skelp to make the full range of pipe from ½ to 4 in. inclusive.

The mills are located in a building 910 ft long and 114 ft 9 in. wide which is served by one 15-ton overhead crane.

The layout and equipment in each of the two mills is similar, varying only with respect to the size and speed variations between each mill. The ½ to 1½-in. mill has capacity to handle 16-in. wide skelp in coils up to 60 in. outside diameter, while the 1¼ to 4-in. mill will handle 18-in. wide skelp in coils up to 60 in. outside diameter. The coils are delivered as required by each mill from the adjacent coiled skelp storage building by either the transfer car or by a self-propelled, 15-ton ram truck and placed in storage racks adjacent to the uncoilers.

A 5-ton jib crane is located at the uncoiler for loading the coils onto the uncoiler feed table. The uncoiler unwinds the coil at 117 fpm and feeds the skelp into the roller levellers.

The ½ to 1½-in. mill has a 9-roll leveller, while the 1¼ to 4-in. mill has a 5-roll leveller.

Directly after the leveller is an upcut shear which can be used for squaring both the leading and trailing edge of the skelp, if required before the flash welds are made. The shear is of the double-cut type, having a straight lower knife and a raked upper knife.

The leading edge of the coil is fed into the flash welder where it is welded to the trailing edge of the preceding coil to deliver an endless piece of skelp to the mills. The welder unit includes flash welder, stripper, pulling and gripping mechanism, side clippers and sheet centering device. The No. 1 mill welder has a 500-kva welding transformer while the No. 2 mill unit has a 750-kva transformer.

Upon completion of the welding cycle, the skelp is guided to the floor and formed into a large skelp loop. This loop provides sufficient skelp storage to assure continuous operation of the mill while the uncoiling unit is stopped and the front end and trailing end of the two coils are welded together. Four magnet roll units are provided to assist the leveller in feeding the skelp into the storage loop.

Vertical pinch rolls located near the end of the loop pull the skelp out of the storage loop and feed it into

Figure 4 — Butt weld pipe is made on two continuous mills, one producing ½ to 1½ in., the other pipe from 1¼ to 4-in.

the furnace. The speed of the pinch roll is varied by an automatic loop control located on the back loop approximately 70 ft from the furnace.

The ½ to 1½-in. mill heating furnace is of the continuous type and has an overall length of 155 ft, 11 in. The furnace has a maximum fuel release of 150,000,000 Btu per hour and will heat 8 in. × 0.099-in. skelp at the rate of 28 tons per hour and 16 in. × 0.191-in. skelp at 45 tons per hour. Three hundred and seventy-four burners, divided into three zones of control, fire through the side walls with the flame impinging directly on the edge of the skelp. Three metallic needle-type recuperators are provided. A 4000-cfm blower furnishes the air blast to the skelp edges as it leaves the furnace for increasing the temperature.

The 1¼ to 4-in. mill heating furnace is of the continuous type and has an overall length of 174 ft 1 in. The furnace has a maximum fuel release of 180,000,000 Btu per hour and will heat 12 in. × 0.121-in. skelp at the rate of 44 tons per hour and 16 in. × 0.337-in. skelp at 55 tons per hour. Four hundred and eighteen burners in four zones of control are provided. This furnace has four metallic needle-type recuperators.

Located directly after the furnace discharge door are the forming, welding and reducing mills. The art of reducing the diameter of the welded pipe from the weld mill and maintaining or reducing simultaneously its wall thickness is accomplished by stressing the pipe in tension between the roll stands. This method of producing 13 sizes having a total of about 50 classifications in the range of ½ to 4-in. pipe necessitates the production of only four different outside pipe dimensions at the weld mill.

The ½ to 1½-in. mill consists of a 6-stand forming and welding mill and a 10-stand stretch reducing mill. The 1¼ to 4-in. mill consists of a 6-stand forming and welding mill and an 8-stand stretch reducing mill. The 16-stand mill is driven by a total of 1200 hp and the 14-stand mill by 1050 hp. Each stand is individually driven by a d-c motor having a 4 to 1 speed range. In each mill grouping, the stands are alternately vertical and horizontal. All rolls are 14 in. outside diameter. Bottom horizontal rolls and back vertical rolls are fixed. Top horizontal rolls and front vertical rolls have vertical and axial adjustment for lining-up grooves. The fact that the lower roll chucks are fixed simplifies size changing since the lower rolls are located against a shoulder on the roll spindle which automatically establishes the line-up of the mill. All rolls have straight bores and are held to the roll spindle by expanding cones and keys.

A 3-stand sizing mill is located behind the last reducing mill, each stand being individually driven by a 50-hp, d-c motor. The No. 1 sizing mill has a maximum speed of 1250 fpm and the No. 2 sizing mill, 650 fpm.

A rotary-type flying hot saw shown in Figure 5 is used for cutting the sized pipe to length. The saw is of the continuous running type with the length of cuts determined by the length and rpm of the crank. The saws for each mill will cut lengths from 18 to 54 ft at maximum mill delivery speeds. Individually motor-driven roller conveyors which operate at speeds greater than mill delivery speeds are provided after each saw to carry the pipe away from the saws to cooling beds.

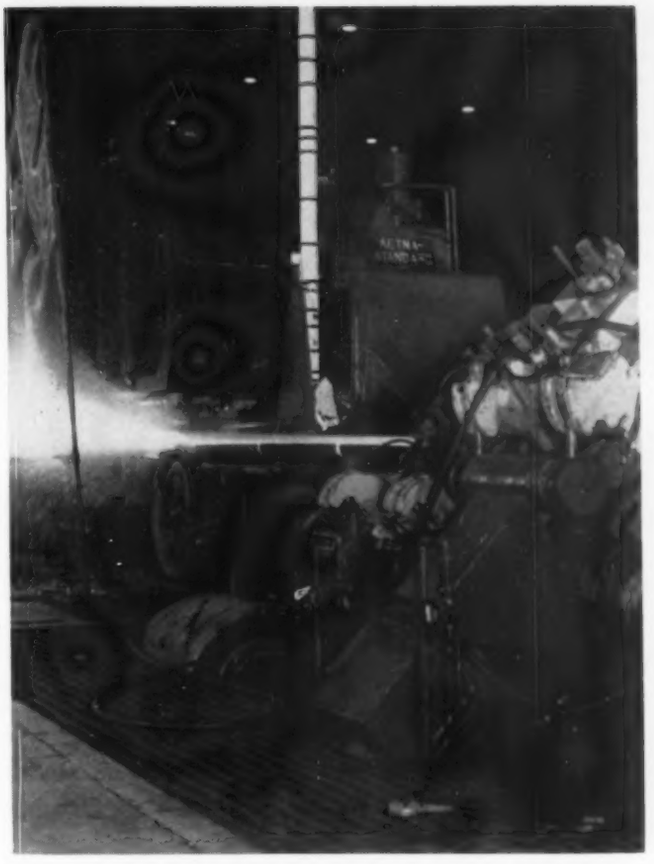


Figure 5 — Pipe is cut to length by a rotary-type hot saw.

Screw-type kickouts are provided to discharge pipe from the saw delivery conveyor to the screw-type cooling beds after which the pipe is passed through a cooling tank.

A screw feed conveyor, with a dual-type splitting saw located in the middle, receives the pipe coming from the cooling tank and on which the pipe is cut into desired lengths. After splitting, the screws feed the pipe onto the inspection skids and thence into the cradles which are located in the adjacent finishing building.

In operating the mills, the electrical control system maintains set speed relationships between the No. 2 pinch roll, the forming and welding stand group, the reducing stand group, the sizing stand group, and the rotary flying saw.

The No. 2 pinch roll, forming and welding stands, reducing stands and sizing stands are connected to a common variable voltage bus supplied from a 1000-kw, 250-volt, synchronous motor-generator set. Bus voltage is maintained at any set value by means of a feed-back rotating regulator.

Between the main bus and the No. 2 pinch roll motor is a buck-boost generator controlled by loop limit switches to maintain the skelp loop ahead of the furnace within pre-set limits.

The forming and welding group is fed from a section bus which, in turn, is fed from the main bus through a bucking generator providing a pre-set percentage speed difference between the forming and welding group, and the reducing group, in order to control tension between these two separated groups regardless of speed.

As an added feature, a pre-set percentage speed difference between No. 1 and No. 2 stands of the forming

and welding group can be maintained for tension control between the forming and welding rolls.

The rotary flying saw is fed from a separate generator and is synchronized with the mill by speed signals from the sizing mill and saw carriage, working into a feedback regulator.

Speed settings of individual stands are obtained by motor field control.

One centrally located oil cellar containing two circulating lubrication systems (one system for each mill) serves all the pipe mill equipment. Circulating lubrication is provided on the drives for the forming, welding and reducing mills, sizing mills, rotary flying hot saws, saw delivery conveyors and kickouts, and the cooling beds.

Two automatic and 13 manually-operated centralized grease systems serve approximately 1400 grease points on the two mills.

PIPE FINISHING

The pipe finishing department includes facilities for straightening, facing, threading, coupling screw-up, testing, washing, coating, inspecting, and bundling the entire product capacity of the two mills. All of the machines, with the exception of a few on the jobbing floor, are completely automatic. They are driven by approximately 310 motors having a total of 2050 hp.

The pipe finishing department consists of three bays known as west, center and east finishing bays, and covers about 250,000 sq ft of floor area.

The layout of the finishing floor deviates, to a certain extent, from past practices as will be noted from the manner in which the equipment was placed. For instance, all threading equipment is located in the west bay which makes it possible to transfer pipe by crane from any of the threading machine outlet cradles to any of the coupling screwing-on machine loading tables, thus providing for maximum flexibility in the utilization of equipment. The location of the threading machines in one bay also simplified the installation of threading oil piping to and from the adjacent oil house.

All coupling screwing-on machines are located in the center bay, and since couplings are loaded and stored in tote boxes at the south end of this bay, rehandling of couplings is reduced to the minimum.

All hydrostatic pipe testing equipment is also located in the center bay, and it is possible to transfer pipe by crane from any single length coupling screwing machine to any of the single length automatic pipe testing machines. A recirculating water system has been provided at the south end of the center bay where water used by all of the testers is collected in a sump, filtered and treated with rust inhibitor before being returned to the individual sumps at each pipe tester for re-use.

All of the pipe coating machines are located in the east bay and it is possible to transfer coated pipe from any of the cradles at the coating machine to any of the six pipe bundling units.

In general, the layout provides means of effecting maximum utilization of equipment which, in turn, permits more flexible operating conditions to be used when required.

GALVANIZING

A necessary adjunct in connection with a pipe mill is a pipe galvanizing department. For this purpose we have provided pickling facilities, two galvanizing units, and the necessary storage and handling facilities for the product and materials.

Pickling facilities consist of one brick-lined concrete caustic tank for degreasing, three brick-lined concrete pickle tanks, each equipped with a 15-ton mechanical pickler, two brick-lined concrete wash tanks for rinsing, and two steel water holding tanks.

A 160,000-cfm exhaust system is provided to remove fumes and vapors from the three pickle tanks and the caustic tank, the fumes being collected on both sides of each tank in neoprene covered steel ducts and carried underground in acid-proof brick-lined ducts to a fume washer where the air is washed with water before it is exhausted by fans into a 75-ft high stack.

The acid contaminated rinse water is piped to an acid neutralizing plant located adjacent to the galvanizing department. Here the acid in the rinse water is continuously neutralized by the addition of hydrated lime, the flow of which is controlled automatically by a pH recorder controller.

Waste pickle liquor is pumped into three elevated wooden storage tanks having a total capacity of 35,000 gal. These tanks are arranged for gravity loading of tank trucks for disposal.

Waste caustic solution is pumped to a steel storage tank near the neutralizing plant, where arrangements have been provided to use it to supplant the lime for neutralizing the rinse water.

Two pipe galvanizing units have been provided, one being of the batch-type while the other is continuous. The batch-type is used for galvanizing ½ to 4-in. pipe in 18 to 25 ft lengths at a maximum rate of 18 tons per hour. The continuous type has been designed to handle ½ to 2-in. pipe at a maximum rate of 30 tons per hour

Most modern means have been employed in eliminating dust and fume laden air through the use of exhaust systems.

WAREHOUSE

To stock the wide range of pipe sizes and classes delivered from the finishing floors, a warehouse 1404 ft long by 129 ft-8 in. wide is provided complete with a 30 ft wide enclosed truckway which adjoins both the warehouse and east finishing bay for their full lengths. The warehouse can hold about 30,000 tons of pipe and shipments can be made either by rail or truck.

All pipe is brought from the finishing floor to the warehouse on bolsters through the truckway by three 35,000-lb capacity straddle trucks. Pipe is stocked in 448 permanent racks by three 10-ton four-hook cranes. In addition to the permanent racks, a total of 96 racks are provided for stocking tallied and bundled loads of pipe to be ready for immediate loading upon arrival of scheduled trucks.

ELECTRICAL DISTRIBUTION SYSTEM

In conclusion, it may be of interest to discuss the distribution of electrical power to operate this plant.

Electrical power is furnished by a main outdoor substation to the motor room by means of a 13.8-kv underground duct system consisting of two independent duct banks in separate concrete envelopes.

Each of the duct banks between the main substation and the motor room carries a main feeder made up of three-conductor 500 MCM type H lead-covered cables. Each of the two feeders so provided is of adequate capacity to carry the plant's entire load, thus ensuring continuity of service. Cables are protected by a pilot wire relaying system.

The nerve center of the electrical system is the motor room which is a completely air-sealed building of sandwich-type, steel panel construction, situated between the skelp mill and the pipe mills. This building houses the 13.8-kv switchgear, 250-volt constant voltage d-c rectifiers and breakers, 440-volt switchgear, 2.3-kv switchgear, skelp mill rectifiers, skelp mill main drive motors, pipe mill motor-generator sets and auxiliary control for both skelp and pipe mills.

The atmosphere in which this equipment operates, as well as cooling air for main drive motors, is cleaned by a 154,000-cfm semi-automatic electrostatic air cleaner. Arrangement of the ventilating system permits induction of fresh air through roof stacks in summer, or recirculation of air during winter.

Concentrated load areas are serviced by a 13.8 kv parallel radial feeder system and unit substations.

By so arranging the electrical facilities, it is expected that loss of production due to electrical failure will be reduced to a minimum, and that provision for load growth can be made for a relatively small future investment.

DISCUSSION

PRESENTED BY

J. L. ROEMER, JR., Superintendent of Tube Mills, The Youngstown Sheet and Tube Co., Youngstown, Ohio.

J. L. Roemer, Jr.: In discussing Mr. Johnson's paper, I think it would be well if we could go back about eight years and compare it with what was thought to be the modern skelp and tube mill at that time.

As reported, the Fairless skelp mill consists of ten stands plus five edging rolls which roll four widths of skelp to produce ten sizes of pipe from large coils which results in fewer end welds. In comparison, the skelp mill of yesterday consisted of eight stands plus three edging rolls to roll eight widths of skelp for eight different sizes of pipe to produce small diameter coils which resulted in more end welds.

At Fairless they have two of the most modern continuous butt weld tube mills consisting of 16 stands on the one mill, and 14 stands on the other, compared to six stands on the modern tube mill of eight years ago. They have the potentiality of producing ½-in. pipe at the rate of 14 miles per hour which is a lot of pipe compared to the old mill at six miles per hour on this particular size.

Some other important comparative data is the fact that they have a 500 and a 750-kva welding transformer at the end welders compared to a 300-kva transformer on the old mill.

They also have magnetic rolls to help push the skelp into a double-loop pit which has a dancer rheostat plus a set of pinch rolls to control the flow of skelp into the furnace. The old mills generally had a set of pinch rolls to push the skelp out into the loop pit which consisted of a single loop, and depended on the forming and welding unit to pull the skelp through the furnace as there was no provision made for the use of a dancer rheostat or pinch rolls.

These new furnaces at Fairless are 156 and 174 ft in length. The smaller one has 374 burners, three metallic recuperators and produces pipe at the average of 28 to 45 tons per hour. The larger unit has 418 burners, four metallic recuperators and produces pipe at the rate of 44 to 55 tons per hour. Both mills have individually driven rolls and a new hot-saw. The older continuous mills are about 146 ft long, have 300 burners, six carborundum recuperators and produce between 13 and 39 tons per hour using a central mill drive for the rolls and a cone-type clutch hot-saw.

In conjunction with the new skelp mill and two continuous furnaces, they have adequate finishing and galvanizing equipment of modern design which is ample to take care of the production from these two fast butt weld continuous mills.

AISE SPRING CONFERENCE

APRIL 25, 26, 27, 1955

HOTEL STATLER DETROIT, MICH.

A New Way to Control ARC FURNACES

By CHARLES W. VOKAC, Manager, Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.

. . . . better arc furnace control will give better furnace economy and operation . .

▲ THE electric-arc furnace is a significant part of our economy today. Its application appears to be boundless and increasing at an unparalleled rate. That progress is due to the cooperative, competitive and ceaseless efforts of many industries, professions, and trades. Among them are the furnace builders who strive continuously to improve the arc-furnace equipment, reduce its costs, and improve its efficiency and operability. Thus, the arc furnace is made available for more new applications and becomes more competitive on existing processes.

A salient part of the arc furnace is the arc-furnace control. Perhaps most attention had been focused upon this part of the arc furnace and most effort, consequently, had been expended upon its development and improvement. This is quite natural. The arc-furnace control is the "business" part of the furnace. It controls the arc from which the heat in the furnace is generated.

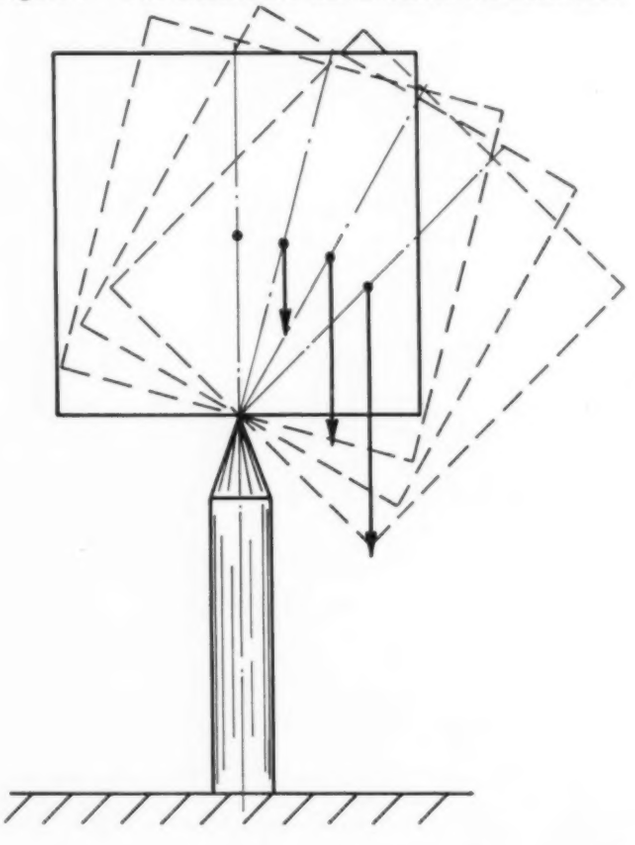
The arc has a peculiar, so-called negative, characteristic. It is extremely unstable and tends to destroy itself with increasing rapidity. Its character may be related to a fragile glass block balancing upon a pinpoint as shown in Figure 1. The slightest disturbance will start it to fall to destruction with increasing moments acting upon it to do so, as the arrows show.

Maximum efficiency from the arc is obtained when the balanced condition is maintained with the least deviation. Obviously, some counteracting means must be employed to detect when the arc (or block) is off balance, which way it is off balance, and proceed to right it without pushing it over in the other direction. All this must be done almost instantaneously, since the arc can get off-balance and extinguish itself almost instantaneously, unless another means is employed to slow the tendency of the arc (or block) to destroy itself.

The first means employed to detect the off-balance and correct it, is the arc furnace control. The second is added circuit impedance which tends to hold up the arc (or block) until the control responds and moves to take over.

The slower the control may be, to respond and act, the more impedance must be added to the system to keep the arc in existence and in production. The slower the control, the farther the arc (or block) will waiver from its highest point of efficiency. The more the im-

Figure 1 — The electric arc has unstable characteristics.



pedance in the circuit, the less energy will reach the arc. Obviously, a control is required that responds and acts instantaneously so that the least amount of added impedance would be required.

Since even the best control will have some lag before it responds and acts, some impedance must be added to the circuit, if inherently there is not enough. Resistance in the circuit impedes all current flow and could be used for the necessary added impedance. But resistance creates heat, and if added to the circuit anywhere but at the arc, the result would be a waste of electrical energy. Reactance in the circuit impedes alternating current flow without creating heat to waste energy; so it is used instead. However, it reduces the amount of energy that can reach the arc; so it cannot be used promiscuously either.

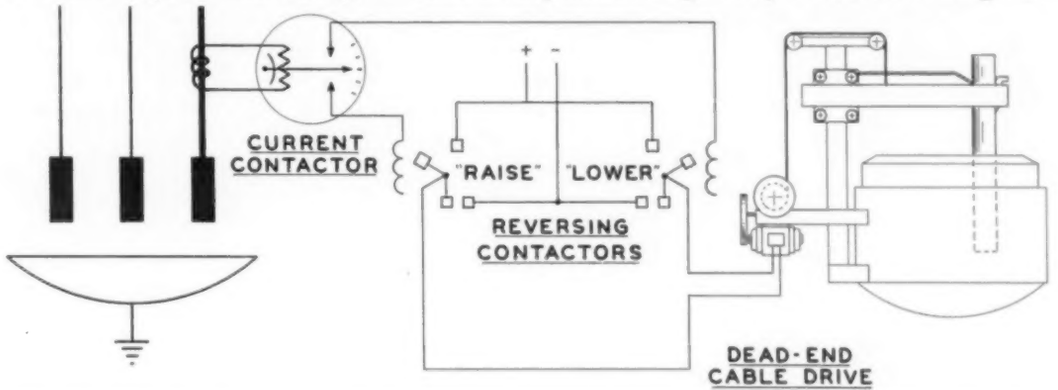


Figure 2 — One method of controlling furnaces was through the use of a current contactor coupled to a dead end cable electrode drive.

A control that will keep the arc at its highest balance will produce the highest load factor, since the latter is the ratio of the energy used by the arc, to the energy available to the arc. A control that responds and acts the fastest, will require the least help from added reactance and, therefore, will operate at the highest power factor, since the latter is the ratio of the energy used by the furnace to energy delivered to the furnace. A control that prevents the arc from getting off-balance, will operate with the best surge factor, since the latter is a function of the magnitude of the surging current in the highline, the duration of the surge before it is reduced and the frequency with which this occurs. It will also balance the load among the phases and thereby improve the power factor too.

A furnace operating at the highest load factor will produce the highest tonnage of iron or steel, and at the lowest cost per ton, other factors being in line of course. (Amortization of the plant and equipment, interest on the investment, supervision, demand charges, radiation losses, and other fixed costs are reduced when divided by the larger tonnage output.) A furnace operating at the highest power factor makes more use of the power delivered to it and reduces the cost of the energy used. A furnace operating at the best surge factor is a good neighbor on the line, makes an attractive load to the power supplier and prompts him to make more power available for these operations with less restriction.

The electric-arc furnace is not a cheap piece of equipment and it uses the most expensive fuel. Yet, this fuel is metallurgically perfect and can be completely converted into useful heat. Considering the tonnage produced from a properly designed and energized furnace, the investment is not weighty. But it requires the most perfect control like any investment or outlay of costs. The furnace control does it well or indifferently depending upon how efficient it is.

Electric-arc furnaces were first controlled manually. The arc loaded down with enough circuit impedance behind it could be maintained manually by a good operator, constantly alert, if conditions within the furnace did not change too rapidly. But when the arc furnace became a production tool in a competitive market the need for automation was obvious.

One of the first automatic controls applied to arc furnaces which enjoyed wide application was the cable hoist arrangement energized by a contact-making ammeter shown in Figure 2. The ammeter was set at a predetermined maximum or minimum arc current. When the maximum or minimum was reached, the ammeter energized the reversing contactors accordingly. The electrode hoist motor turned forward or reversed accordingly to raise or lower the electrode. The increased or decreased arc gap, between the electrode and the burden, increased or decreased the arc resistance to current flow. Thus, the arc current was, conversely, decreased or increased, respectively.

This control responded only to arc current. It had no direct control over the arc gap, or the arc voltage. A limit switch was added to a later model to stop electrode dipping, but it was obvious that absolute control of both the arc current and the arc voltage was necessary to control the arc heat energy.

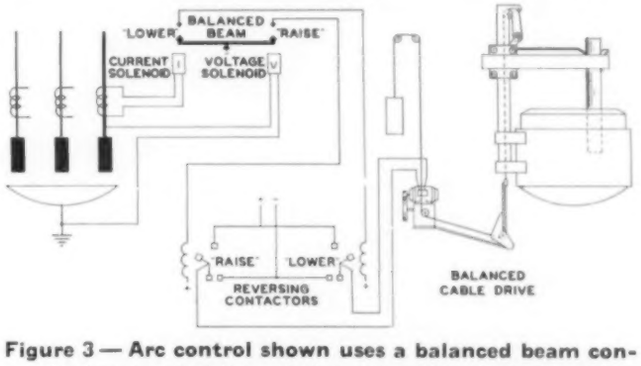


Figure 3 — Arc control shown uses a balanced beam contactor coupled to a balanced cable electrode drive.

The electrode hoist was necessarily heavy and consequently high in inertia. It was slow to respond to the rapidly changing conditions. It was slow to correct them. Larger motors to make the electrodes move faster only added inertia to make them more difficult to reverse. Smaller motors reversed easier, but overheated under the load and from the rapidly changing currents to raise and lower the electrodes. Dampening

the ammeter alleviated this condition but that reduced its sensitivity to arc off-balance and slowed correction.

The improved control shown in Figure 3 eliminated or at least alleviated some of those and other problems. A balanced-beam type of relay replaced the contact-making ammeter. A balanced electrode hoist replaced the unbalanced hoist. The electrode hoist motor, speed reducer, and spur-gear train were removed off the furnace, out of the heat, dust and magnetic influence of the secondary circuits, and placed into the control room where it is cleaner and cooler.

The relay was balanced between a predetermined arc current and a predetermined arc voltage. Thus, it responded better to both factors which multiply to produce heat. But, like the other control, it responded only to maximum or minimum off-balance conditions of the arc. And so the electrode was driven upward or downward at full speed, whenever a correction was required, even though the amount of correction needed was slight. The results were considerable overtravelling, hunting, surging, etc. Dampening this relay, like the previous one, with oil-filled dash-pots and spread-out contacts helped to reduce this problem, but it desensitized the control and made it slow to act. A later model had a half speed feature that responded to partial off-balance conditions. This was only a half solution to the problem, but it helped.

The reversing contactors were still used as before and these required a good deal of maintenance and attention to keep them in working condition.

Balancing the weight of the electrode and its moving parts with a counterweight, reduced the load considerably on the electrode hoist motor, speed reducer, etc., and reduced their size to half even with electrode speeds doubled. This reduced the inertia of the mechanical system considerably so that the system could reverse quicker and oftener according to the demands of the furnace. However, the inertia in this system was still a sizable factor. The counterweight, additional cable, sheaves, etc., all added inertia, offsetting partly what was gained. The increased cable lengths and friction-biting on the drums, increased the cable maintenance. The longer cables, smaller in diameter because the sheaves were reduced in diameter due to space limitations, increased stretchability. That, and the lost motion in the reversing worm gears and spur-gear backlash reduced the response of the control. Limit switches on the previous control, here were only partially eliminated.

Further development produced the control shown in Figure 4. The balanced-beam relay and the reversing contactors were replaced by the special differential field rotary generator shown here. The balanced cable hoist was replaced by the air-counterbalanced hydraulic electrode drive.

The control responded to both the arc current and the arc voltage, but it balanced one against the other in such a way that the differential between them was amplified by the generator to operate the electrode motor. Thus, the electrode motor was not only reversed according to arc off-balance but the energy to the motor was controlled according to how much the arc was off-balance. This was accomplished without the use of reversing contactors, improving response time, and eliminating maintenance of points and arcing contacts.

The air-counterbalance eliminated the added inertia of the counterweight. Cables, sheaves, special linkages, limit switches, speed reducers, all have been eliminated and with them the added friction, lost motion and inertia.

Hydraulics are a "natural" for controlled reciprocation of heavy masses. The hydraulic system is relatively frictionless. The fluid is relatively incompressible resulting in smooth action with almost no lost motion. Non-flammable hydraulic fluids are available now at reasonable cost and with good characteristics. Compatible packings have been developed too.

The friction in the system being reduced and the air-counterbalance being more efficient, the electrode motors were again halved in size and the electrode speeds were further increased for greater response to arc off-balance and faster action for correction.

Until quite recently, this was the best arc furnace control available. But, it was still lacking in many respects, as experience with it made quite evident.

This control draws up to 10 amperes of current from the secondary current transformers on the furnace bus. It draws another equivalent amount directly from the bus. Most of all this is dissipated in resistors and field coils and the small difference left over is reamplified with more power driving generators to regenerate a few amperes to drive the electrode motors. If the signal from the furnace bus were a feeble one, requiring amplification before it could drive a motor, the use of the special differential field rotary generator could be justified. However, there is more power in the furnace bus than is required to drive the largest electrode motor that will ever be used. Obviously, there is no need for this extra machinery, the extra circuit complications it required, the extra maintenance and the extra time lag it introduces, reducing the speed and response of the control.

This control, like the others, still uses reversing electrode motors. They must move, from standstill position, the weight of the electrodes, electrode clamps and supports, copper bus bars and copper cables. No motor can do any real work from standstill position. The generators must push high starting currents into these motors to get them even started. These currents only heat up the motors when they are constantly and rapidly changing from plus to minus as when the furnace is "in business." A motor can develop its full rated power only when running at full rated speed. It can do its job efficiently only at or near its rated rpm.

The special differential field rotary generators try to regulate the speed of the motors in proportion to the arc off-balance. But, since high starting currents are required to get the motors moving one way or the other, the control was found to be insensible to over 60 per cent of the range of arc off-balance. Consequently, this control does little more than what the contactors do—reverse the motors only when the arcs are appreciably off balance. The motors will not respond to the fine differentials from standstill position.

Motors keep cool when the current flowing through them is nearly proportional to their speed. At, or near, standstill position, motors cannot cool themselves to dissipate the heat generated within them by the rapidly changing heavy starting currents.

It is commonly believed, as stated before, that this control balances the arc current against the arc voltage, and the supposition is made that this controls the arc energy—heat input. Actually this control balances energy drawn from the secondary current transformer, which is proportional to the arc current, against the energy drawn directly from the bus, which is proportional to the arc energy. Something cancels out and the result is not control of arc energy, which is that desired.

To prove the point, on furnaces using a rotary generator, disconnect the secondary current transformer in each phase. Be sure to short the terminals so it does not burn out; or better still, remove it from the bus entirely and it will not feed back to distort the sine wave. Apply a constant a-c voltage to the rectifier terminals disconnected from the secondary current transformer or remove that rectifier and apply a constant d-c voltage to that field coil of the generator. (The a-c or d-c voltage applied must be absolutely steady and not fluctuate. It will act as a standard against which the regulator will operate.) Start the furnace and note the result. One should find that the arc is smoother and that more reactance can be removed from the circuit to increase the power factor and increase the useful energy going into the furnace.

With balanced beam control, the same test can be made by applying a constant d-c to the current coil of the beam.

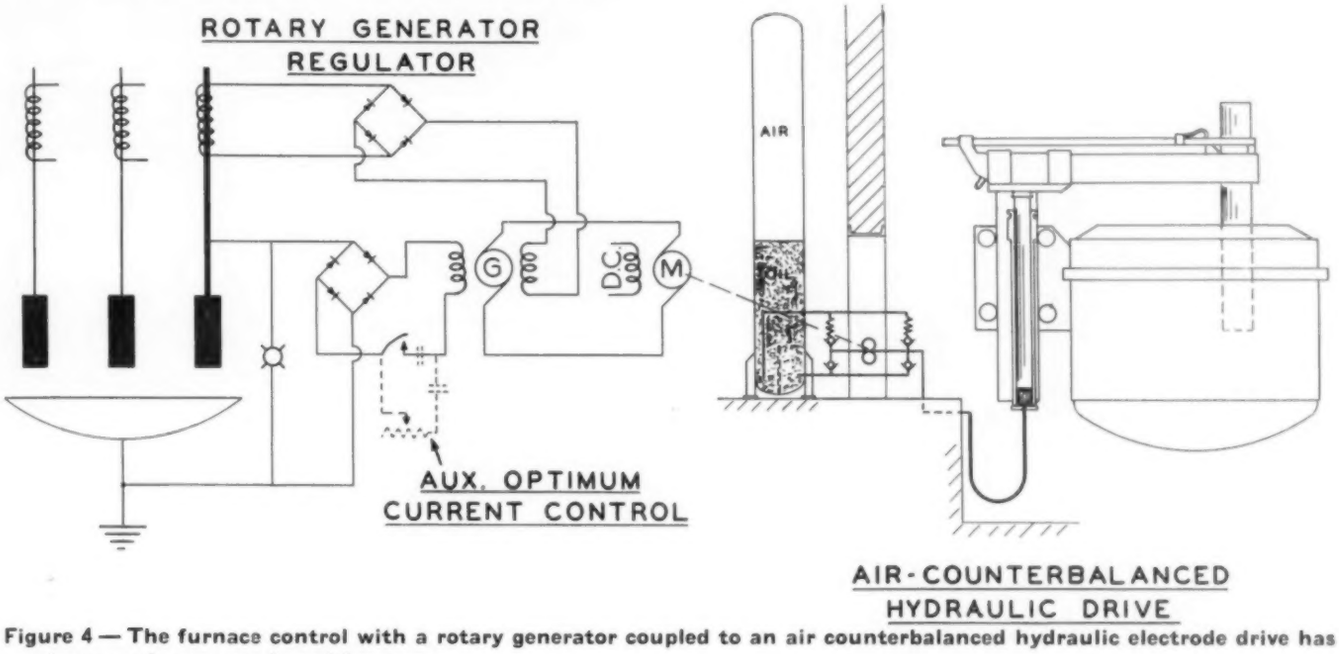


Figure 4 — The furnace control with a rotary generator coupled to an air counterbalanced hydraulic electrode drive has been used on a number of furnaces.

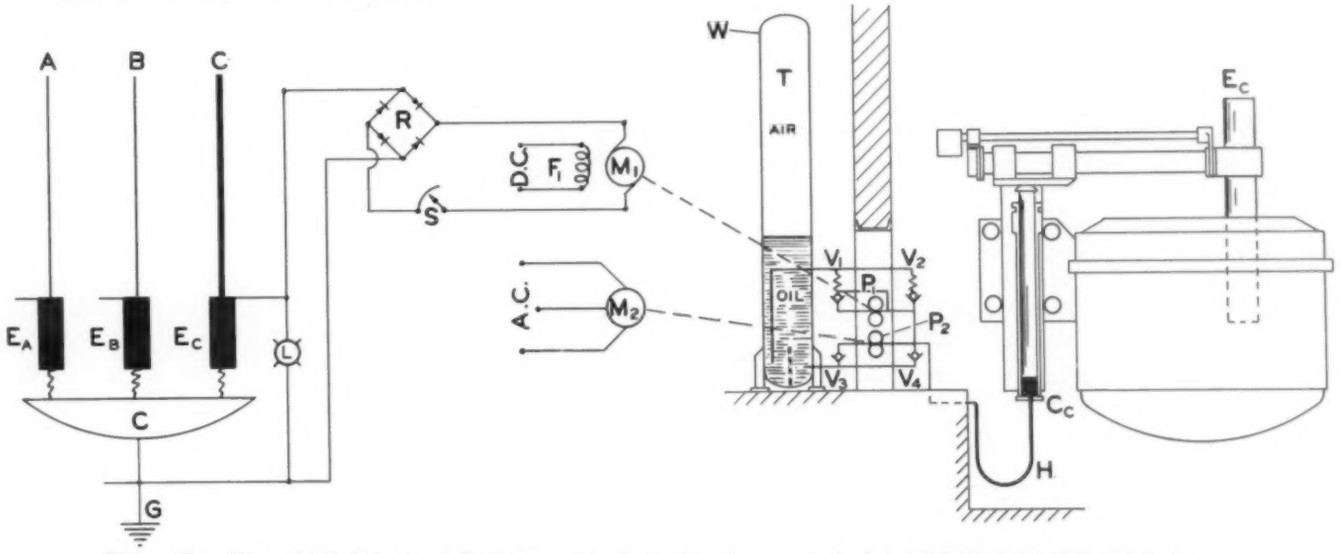


Figure 5 — One of the latest arc furnace controls is the air counterbalanced hydraulic differential type.

These regulators, under adverse conditions of operation, were observed not to respond to wide changes in arc lengths even when the arc lengths increased as slow as one inch per second. They were observed also to get completely out of balance at the slightest variation in the high-line voltage. The poorest regulation was obtained on meltdown when the best is needed. This control does not have a fixed standard reference against which to regulate.

With so many characteristics working against this control, a new control was developed as shown in Figure 5. This is a fundamentally different type of arc-furnace control from any other arc-furnace control ever built. It is a hydraulic differential energized directly

from the furnace bus. It eliminates the special differential field rotary generators. Its electrode motors are driven directly from the furnace bus with no time lag. (The motors are operated directly by the signal.) They draw energy, from the bus, which is inversely proportional to the energy of the arc—not just any current and any voltage. It takes the right combination of these two to make the desired energy (heat) in the furnace. This control, controls that combination.

With the elimination of the special generators went the circuit complications, the maintenance, the time lag and the special secondary current transformers with their tempermental characteristics.

The electrode motors in this control are unidirectional; they do not reverse; they run only in one direction. The advantage of this is quite apparent. Electrode motors maintain proportional characteristics above about 13 per cent their rated speed. The motors in this control do their regulating considerably above this point and not below it. They regulate at or near rated speed where they have the power and can develop energy necessary to do the job correctly, conveniently, and quickly. (One can accelerate or decelerate a car from 50 mphr to 60 mphr easily and quickly but from 5 mphr forward to 5 mphr rearward is something else. Does it require the same energy? Theoretically yes, but actually the reversal of strains absorb more energy and the energy is not available at the reduced motor speed.)

Electrode motors operating at or near rated speed do their job without overheating and straining. At these speeds they cool themselves and do not require high, suddenly applied torques to develop the required horsepower and to do the required work.

Since even minute changes in current or torque near rated speed result in proportional changes in the speed of the motors and electrode, this control actually regulates the electrode speed in true proportion to the arc off-balance over a much wider range.

The electrode motor that does all the work of supplying the required pressure to lift the unbalanced part of the electrode load is a constant speed motor, eliminating the problem of inertia just as reactance is eliminated in a d-c circuit. (In fact, serious consideration is being given to putting a flywheel on this motor to obtain from it the added energy for instantaneous acceleration of the largest electrodes.) This constant speed a-c motor is the fixed, standard reference against which the furnace is regulated and nothing happening within the furnace or power supply to the furnace can upset it to make the control get off balance, hunt or surge.

The overall time lag of this control, that is, the instant when a signal is received from the bus, to the instant when the electrode actually reverses in response to this signal, is 0.05 sec. None of the other controls even approach this. The speed of the electrode with this control was also increased considerably and compatibility with response and acceleration was maintained. Higher electrode speeds were tried with the other controls but because they were slow to respond and slow to act, furnace operation became worse instead of better. Higher electrode speeds are desirable but they must be accompanied by faster response and greater acceleration and deceleration; otherwise, they will make the furnace operation worse instead of better.

The new control has been thoroughly tested in the laboratory and in production. New furnaces are now being equipped with it.

The following tells how the new control works: Referring to Figure 5, motor N_2 is connected directly to pump P_2 which pumps liquid from the tank T at a constant rate to the cylinder C_c. Motor M_1 is connected directly to pump P_1 and it pumps the liquid away from the cylinder C_c, returning it to the tank T. When the motors are running at the same speed, pump P_1 returns all the output of pump P_2 and the electrode does not move.

When motor M_1 slows down or speeds up, the difference in the output of the pumps either raises or lowers the electrode. Now the motor M_1 speeds up or slows down according to the amount the arc is off balance. Both pumps are metering pumps. Pump P_2, doing all the work, is running at constant speed. Pump P_1 acts only as a metering valve, since the pressure across its ports is balanced. It changes speed only in proportion to the arc energy. Metering pumps give volumetric control for precise control of the electrode travel. They do not have valve lands to result in lost motion and loss of control, and do not have the usual port registration difficulties encountered with some valves.

An analysis of Figure 5 will show how the control reacts upon start of operations. All three electrodes, in a three-phase furnace, are set just above but not in contact with the scrap or burden to be melted or heated in the furnace. The control is started and the electrodes are energized. Motor M_1 draws full voltage and energy from the bus and runs at twice the speed of motor M_2. The electrode lowers at full speed until it makes contact with the burden. Either of two things or both happen at this instant depending upon whether the contact is mechanical or electrical or both.

If the burden is corroded or covered with non-conducting material, such as rust, scale, dirt, etc., as in most scrap, only a mechanical contact will be made and motor M_1 will continue to try lowering the electrode. But, when the electrode made a mechanical contact with the burden, a part of its weight was shifted off the cylinder and the pressure dropped in the cylinder. Check valve V_4 prevents the pressure in the cylinder from dropping below the air-counterbalancing pressure in the tank. Thus, this valve prevents an excessive shift of weight off the cylinder to the electrode. The electrode, made of graphite, or carbon, is quite brittle and cannot safely support the weight of itself, the electrode arm and clamp, heavy copper bus and cable. Valve V_4 permits pump P_1 to run indefinitely at top speed or until the mechanical contact also becomes an electrical contact. Usually, this happens without special attention, even with exceptionally dirty scrap, especially when electrode voltages are high enough.

When the electrode makes an electrical contact with the burden, the voltage and energy to motor M_1 is shorted through the electrode and motor M_1 slows down. Since motor M_2 is running continuously, the electrode goes up as soon as the speed of Motor M_1 passes the speed of motor M_2. If neither of the other two electrodes made contact with the burden, no arc current will flow. So, this electrode will continue to rise until contact with the burden is just broken. Then the electrode will again lower as before and rise again, con-

tinuing the cycle until another electrode makes contact with the burden. At that instant, current will flow through those electrodes. Since the electrodes play lightly on the burden, arcs are instantaneously formed. This prevents the usual, heavy, short-circuit current flow encountered with the mechanical furnace controls. Motor M_1, getting energy inversely proportional to the energy of the arc, will speed up, slowing down the upward travel of the electrode until the maximum arc energy is reached (or some predetermined maximum is reached) when the output of pump P_1 equals the output of pump P_2 and the electrode holds its position at the proper arc length.

Any change of conditions, such as the electrode burning away, the burden melting down, or the main line voltage fluctuating, etc. will cause the control to make correction within 0.05 sec.

Valve V_2 acts as any other relief valve in a hydraulic system. It relieves the pressure in the cylinder when the electrode reaches the top of its stroke. It also prevents undue pressure that would break an electrode, if it became fouled by cave-ins of the burden, etc. Electrodes usually free themselves, without special attention, when this happens. But when this happens with mechanical controls, the electrode breaks, or the cable parts, or a pin shears, or the motor stalls before the electrode clears itself.

The air-counterbalance pressure, in tank T, is set to counterbalance the minimum weight on the cylinder C_c. Electrodes are consumed and new lengths are screwed on to extend them. Thus, the weight on the cylinder creates a greater pressure than the air-counterbalancing pressure, at almost all times. The pumps have some slip even when new and more as they wear. When either one, or both pumps, are stopped, the fluid would pass from the cylinder to the tank and the electrode would drift down slowly. Valves V_1 and V_2 are used here to prevent this.

The hydraulic system, like the motors, is unidirectional also. The pumps get a fresh, cool supply of fluid at all times. The entire system is totally enclosed. Packing glands are double-sealed and vented. The cylinders are torque-free at both ends preventing transfer of any moments, to strain the glands laterally.

In summary, the new control means this:

1. Fewer working parts. The furnace regulator is eliminated.
2. Fewer working parts mean less maintenance.
3. Lower electrode consumption, unless the electrode consumption is already down to 6 lb per ton as at Kensington Steel. (This furnace already had a hydraulic control when this new control was put on it.)
4. Less circuit reactance.
5. Higher power factor.
6. Higher load factor.
7. Reduced energy consumption. (On an average 30-day operation, the energy was reduced 5.7 per cent from 520 kwhr per ton to 490 kwhr.)
8. Greatly simplified circuits.
9. Unidirectional motors.
10. Faster action.
11. Faster melting, heating, or smelting. (Heats are produced in 95 minutes when the record previously was 115 minutes).
12. True regulation in proportion to arc off-balance.
13. Longer refractory life. (A 12 per cent reduction in refractory costs is reported).
14. Arc regulation over a much wider range.
15. Instantaneous response. (0.05 sec from a signal to stop an electrode going at full speed and actually reversing it).
16. Smooth arcs that flash downward. (This is quite a noticeable effect which can be repeated at will. On its first trial run, the control was labeled a "Boring Machine." It bored right down through the charge leaving less than ¼-in. clearance around the electrode. There was not enough metal displaced to cover the bottom refractory sufficiently. And when the charge was melted down, there was unmelted metal all around near the refractory. The arc heat was concentrated downward and into the center. We removed just enough reactance out of the circuit to flare out the arcs. This opened up the bored holes as desired, and it spread out the arc heat just enough to reach the metal near the refractory without melting out the refractory. Hence, the reduction in refractory costs. The reactance taken out resulted in a higher power factor. More heat was put into the furnace and the transformer operated 10 to 15 degrees cooler, it was reported. To us it meant also that more heat from larger transformers could be driven into a given size furnace, with this control, without melting out refractories.)
17. Losses were, therefore, lower.
18. The number and the intensity of line surges were reduced.
19. Solid, dead short circuits were eliminated.

There is no change in the operator's panel so that no extra skill or training is required to use this new control. Convenient interchangeability of all parts is maintained and the control is made of standard, easily procurable parts.

Continued progress, such as this, in the improvement of the electric-arc furnace, the automatic electrode clamp now universally accepted, the top charge and high powered transformers will maintain its unparalleled rise in our national economy.

DISCUSSION

PRESENTED BY

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E. A. HANFF, Vice President, Swindell-Dressler Corp., Pittsburgh, Pa.

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CHARLES W. VOKAC, Manager Hydro-Arc Furnace Div., Whiting Corp., Harvey, Ill.

D. R. Cochran: Now and then, a new arc furnace electrode regulator is introduced to the public. A new development always draws attention, but eventually

there comes a time to sit back and take a good look at the newcomer to determine whether it is actually advancing the art of electrode regulation. This seems to be the time to evaluate the electrode regulator just described.

We are pleased to have the opportunity to discuss the regulator which the speaker described, because we built a control panel for the author's company in accordance with their requirements, for use on the furnace where the new control was developed.

To give a basis of evaluation, it is first necessary to review some of the characteristics of a rotating type electrode regulator, with which most operators are acquainted. This type regulator regulates arc current against arc voltage as a reference. However, the paper was not clear in the explanation of why this is done. Arc voltage is used as a reference with two specific purposes in mind. First, arc voltage acting as a reference provides an automatic undervoltage signal to stop an electrode when it touches the metal in the furnace. Second, it makes the arc current regulator on each phase completely independent of the other phases.

As we all know, the use of a rotating regulator to drive the electrode motor offers many advantages, some of which are as follows:

1. A rotating regulator has the ability to respond to a combination of an arc current signal and an arc voltage signal to give an automatic under-voltage signal plus independent phase regulation.
2. The voltage changes at a rate within the commutating ability of the electrode motor when a change is required.
3. A rotating regulator amplifies the arc current error signal so that rated electrode speed is obtained with only a small change in arc current.
4. The excitation requirements of such regulators are very small which permits all switching for manual and automatic operation to be done by pistol grip type control switches directly.
5. A rotating regulator readily accepts pump back current to permit electrode motor deceleration equivalent to the acceleration.
6. Since excitation requirements are so small, control transformers and control rectifiers are small and require essentially no adjustment after the initial installation.

Some of these characteristics require further discussion to determine their merit and to compare them with the regulator which the writer described.

A rotating regulator regulates arc current using the rectified signal from a current transformer. It is able to do this because of its low excitation requirements, which permits the use of a current transformer with the normal 5 ampere secondary. Although both arc current and arc voltage have a definite relationship to arc kilowatts, arc current is the logical choice to represent arc kilowatts because it has a wider variation for a change in arc length, permitting the regulating system to more easily detect a variation from the preset reference.

The regulator described by the author regulates arc voltage, which is less desirable; because the amount of reactance in the supply circuit and in the furnace transformer primary and secondary circuits affects the characteristics of the regulator. Since it regulates arc voltage, it works best when there is a large change in arc voltage for a change in arc length. This means that it requires a large amount of circuit reactance for the best performance. Of course, reactance lowers the power factor as we all know.

Since the author's regulator regulates arc voltage only, a change in the arc voltage of one phase affects the arc voltage of the other two phases, resulting in unnecessary movement of the electrodes on the other two phases.

Speed of response in itself is not important. It is the combination of speed of response and the rate of electrode travel for a given error signal that is important. The new regulator requires a 100 per cent change in error signal to achieve 100 per cent electrode speed. In other words, if the furnace is operating at a given load condition with the electrodes stationary, open circuit voltage is required to get 100 per cent lowering speed and a short circuit is required to get 100 per cent raising speed. Thus, it takes a long time to correct small errors even though its speed of response is good.

With the regulator described by the author, switching from automatic to manual control must be done with contacts on units rated approximately 1 hp and above. Also, since the electrode motors are driven by the rectified arc voltage, they cannot pump back for rapid deceleration.

Thus, it can be seen that there are a number of points in which this regulator is different from the tried and proven type. All of these deficiencies could be overcome by the use of rotating regulators, arranged to regulate arc current, to drive the electrode motors. Rotating regulators on this electrode regulator will give it all the advantages of present rotating regulators while still retaining the unidirectional electrode motors. It makes no difference to a rotating regulator whether the electrode motors reverse or always run in one direction.

Therefore, we can come to only one conclusion, that a rotating regulator would improve this regulator.

Before finishing, I want to offer a word of caution. In his paper, Mr. Vokac suggested that those who are using electrode regulators which regulate arc current by comparing it with arc voltage change them so that they will be regulating arc voltage. We feel obligated to tell those now using rotating regulators that this is not advisable. The rotating regulator was designed to regulate arc current because arc current is the most logical quantity to regulate. Any change such as suggested by Mr. Vokac, although it may work after a fashion, will only sacrifice regulator performance.

E. J. Borrebach: We have heard with some interest this paper concerning a new type of arc furnace control. The use of non-reversing motors to obtain electrode motion is a new approach to the old problem of obtaining good electrode regulation. The scheme discussed is intimately tied in with the hydraulic method of driving the electrodes, and is now at work on at least one arc furnace.

Over the past several years we have developed two different types of electrode control which have been applied on numerous arc furnaces.

One is the balanced-beam type control that responds to current and voltage changes in the arc and that controls the electrode motors through reversing contactors to drive the electrode in the proper direction to correct the arc change. The electrode motor is started

under rated armature current conditions which means that the electrode is fast to respond to the needed correction. However, if the current coil for example should unbalance the beam because of an increase in arc current, the beam will tip in the proper direction to drive the electrode upward. At the same time, part of the current coil will be shorted out by a contact so that the coil will exert less pull on the beam. Thus the beam will be brought back to neutral position and the motor dynamically braked unless the unbalance in the arc is very large. We have experienced no hunting or overtraveling with this type of control when it has been maintained in proper adjustment. This regulator is still being produced and is doing notable work in many instances on present-day furnaces.

The second is a rotary regulator type control that also responds to current and voltage changes in the arc. The signals are applied to two opposing fields of a multifield exciter. The electrode motor is energized by the exciter and a generator to drive the electrode to the proper position for best furnace operation. This control has been applied to the largest arc furnaces having shell diameters of 22, 24, and 24 ft 6 in., and have shown themselves able to give excellent regulating characteristics. For example, a change of only 5 per cent in arc current or voltage will be compensated for in these large furnaces by swift and proper electrode motion; on furnaces with about half these shell diameters a regulation of about 2 per cent can be expected.

The characteristics of the arcs in a steel furnace is a subject which has perhaps not been discussed in the past as much as its importance deserves. The need for an electrode regulator is to maintain constant arc conditions in the furnace, and its performance is tied in directly with the arc characteristics.

In a typical voltage—current characteristic curve of an arc, as the arc current increases the voltage drop across the arc decreases. It can therefore be seen that if an attempt is made to operate at any given point on this characteristic, any change in voltage or current will cause the arc to drive to open circuit or short circuit conditions. This means the arc is inherently unstable, and an impedance must be added into the circuit to obtain stable operation, represented by a combination voltage—current characteristic which rises. No electrode control can maintain a stable arc if this characteristic is drooping, and of course with a rising characteristic the arc is inherently stable. In the steel furnace the arc continually melts away the steel and the arc length and its make-up is always changing for that reason. The regulator is therefore an arc size regulator, and tends to maintain the arc at the length and diameter desired by the operator to give proper energy input and proper spread of that energy by conduction and radiation. It is to be noted that the size of the arc will determine the energy input to the furnace. The balanced-beam or the rotary type of regulator uses both the arc current (a measure of arc diameter) and the arc voltage (a measure of arc length) in order to give proper arc operation. Of course, operation can be obtained through voltage of current signal alone. In the case of current alone, electrode dipping into a molten bath can occur due to the absence of arc length signal. In the case of voltage alone, the signal must be taken far enough back from the arc itself so that the voltage measured will be intermixed with voltage drop from the furnace bus circuit. This gives a voltage signal dependent on arc current and which varies sufficiently to operate a regulator. There is no reason why such a voltage signal alone cannot be used to control a furnace rather than a combination of voltage and current signals; this may be a subject for further study.

E. A. Hanff: In this paper there are a number of statements and claims with which other manufacturers and furnace operators may not agree. Mr. Vokac implies that a greater speed of regulator response will reduce the current surges and permit use of less impedance in the circuit. Actually, the speed of response does not necessarily affect the magnitude of a surge and can only shorten the duration. The instantaneous current is determined by the applied voltage, and the total impedance in the circuit at the moment of contact. This current will persist for several cycles or until the electrode has moved to increase the arc resistance. The response of 0.05 sec claimed would be 3 cycles in a 60 cycle system. Actually in modern installations the amount of reactance engineered into the furnace and transformer is about the same as used in the earliest furnaces for comparable voltages.

The regulator under discussion employs a voltage-sensitive element only, although we are actually interested in controlling the amount of energy or kilowatts in the furnace. Many years ago it was found that the combination of voltage and current elements improved the regulation. In the first part of this paper in discussing the shortcomings of the earlier Seede type current-controlled regulator, Mr. Vokac states, "It was obvious that absolute control of both the arc current and the arc voltage was necessary to control the arc heat energy." If we change the tense of the verb to read, "is" instead of "was," I think we can all agree with his statement.

Of course, a regulator should adjust the electrodes to correct an unbalanced condition as rapidly as possible but, at the same time should not be so sensitive as to be constantly in action in response to minor fluctuations. The modern rotary regulators, when properly adjusted, are giving excellent results in a great many installations.

Many operators and maintenance men will still express a preference for complete electrical operation of electrode mechanism over the hydraulic system. Both hydraulic and electric systems have their individual good and bad features and we may expect to see continued progress in improving both methods of operation.

George D. Lawrence: Mr. Vokac has done much thinking on this subject, and his paper is interesting. I cannot say that we agree with it entirely. We believe that the control of arc current and arc voltage, as advocated by the two electrical equipment manufacturers, is necessary for proper control of the arc. After all, the power in the arc is a function of the voltage across the arc and the current in it.

We use the electro-mechanical winch type electrode mechanism, uncounterweighted, with rotating type control. We have found this system to be very satisfactory in all the installations we have made. The response of the rotating type control appears to be very fast and entirely adequate.

On the large 24 ft 6 in. diameter shell furnace, recently completed, we have increased the base electrode speed to about 50 in. per min and find improvement in the smoothness of operation with the high-power high-voltage transformers.

Charles W. Vokac: The author appreciates the time and effort put into the formal discussions. Since our furnace control is new, it is not yet widely used. The author and commentators represent arc-furnace builders and suppliers to arc-furnace builders. Comments from users of the new control will be interesting too when they have had experience with it.

One such user had already expressed himself in periodicals and society meetings. (There will be others.) He reports 8400-lb heats of basic manganese steel melted and finished without oxygen in not much more than an hour and with only an 1800-kva transformer. Energy consumption, he reports, averages between 485 to 495 kwhr per ton. Some heats are finished as low as 430 kwhr per ton when not interrupted by demand limitation. He reports the number and intensity of surges is reduced, yet the reactance in the reactor is reduced to 20 per cent where 25 per cent and even more is normally used. He reports the power factor is higher and, of course, it would be with that reactance reduced. He reports maintenance as nil, refractory costs 12 per cent lower, and electrode consumption at only 6 to 7 lb per ton and this includes breakage. He reports the transformer runs 10 to 15 C cooler even though it produces the heats faster. Of course, if should with the phase loads more evenly balanced. The energy used is lower for this reason too. With balanced loads and less surging, arc furnace transformers can be built more like power transformers at less cost to the user without the extra bracing, "beef," and cooling to absorb and dissipate that extra energy—also costly to the user. The power supplier appreciates this too.

The introduction of this new advance in arc-furnace control drew general attention in much less time than a similar introduction of the now universally accepted automatic electrode clamp. Therefore, widespread acceptance of this new advance is anticipated within a much shorter time.

The arc-furnace control is a single integrated unit. The commentators, perhaps due to their respective division of responsibility, try to divide it into two separate parts as the old controls are divided into a furnace regulator and an electrode positioner. Consequently, most attention was focused on the one part of their responsibility with inadequate emphasis placed upon the other and the overall performance. The result from the whole control must be discussed and not from only a part of it. Mr. Borrebach did state, however, "The scheme discussed is intimately tied in with the hydraulic method of driving the electrodes, and is now at work on at least one arc furnace." Mr. Cochran avoided any discussion of how the output of the amplifying generator would move the electrodes. He did infer, however, that it would do a better job with the non-reversing motors of our control.

The author discussed the various old furnace regulators and electrode positioners as they appeared together in history. It should be pointed out that each of the three furnace regulators shown in Figures 2, 3, and 4 may still be found operating any one of the electrode positioners shown in the same figures.

Some had replaced one furnace regulator with a newer one. Some of these reported an improvement in furnace operation but too many reported no notable change. All, however, reported reduced maintenance where the contractor types were replaced by the rotary generator types. Yet, some prefer the simplicity and the lower initial cost of the balanced-beam contactor over the rotary generator types.

Many inquired about modernizing the electrode positioner on their furnaces too. But changing the cable drives to hydraulic is not as simple a procedure as changing a furnace regulator and, therefore, it is more costly. In many of these cases, the electrode clamps, arms, carriages, charging arrangement, etc., were obsolete too. Several had simply replaced the old furnace with a new one. Some sold the old furnace or melted it in the new, and thereby recovered the small difference, at least in part, between the cost of the new furnace and modernizing the old one.

All the commentators recognize (Mr. Borrebach specifically) that good electrode regulation is an old problem and that the use of non-reversing motors is a new approach to it. The electrode positioners and the furnace regulators of the old controls have been in use now for a good number of years. If the old could not be improved, the new would not receive the widespread interest already shown in this control. It is not another variation of the old furnace regulator. It is a completely new furnace control that needs no contactors or generators; it is doing a better job without them.

The commentators separate the arc watts (arc heat) into two components, deal with each separately without respect to the other and then throw them together assuming the net result is a simple combination of the two separate results. Metallurgists, particularly, appreciate the fallacy of this sort of analysis—this sort of evaluation. Without voltage there cannot be any current flow. And, conversely, a volt meter never did read anything without current flowing through it. One component cannot be analyzed without giving due consideration to the other. True, in many cases, the effect of one upon the other is negligible or controlled, and when that fact is known, the simple analysis is acceptable. But, in this case, the effect of the arc current upon the arc voltage and vice versa is certainly not negligible nor controlled independently due to a particular characteristic of the arc, making it unlike any other resistor used academically, ordinarily. This fact is known and Mr. Borrebach illustrates it in his discussion. It cannot be ignored in any evaluation of arc-furnace circuits. Therefore, since arc current and arc voltage are each sizable simultaneous dependable variables, a true analysis of any arc furnace control must deal with energy which is the product of the instantaneous voltage and current. For the same reason, many problems in mechanics are solved only with formulas dealing with energy.

Many, for years, (perhaps for convenience) considered that which the secondary current transformers in an arc-furnace circuit delivered as being only current proportional to the arc current. Certainly the two are directly proportional, within certain limits and under certain conditions; but, that is not questioned here.

Actually, it is energy that these transformers or any transformer deliver. Can this energy be exactly proportional to the arc energy? The answer to this question is obvious.

Many, for years, (perhaps for convenience also) considered the tap on the furnace bus and to ground as only a voltage tap, delivering only voltage proportional to the arc voltage. Again, of course, it is a voltage tap and how nearly proportional it is, depends upon how closely the tap is made to the arc ends. Even then it picks up an undesirable reactive voltage drop in the arc which requires compensation as Mr. Borrebach pointed out. And again, it is also an energy tap. The energy from this tap is as perfectly, inversely proportional as an arc signal must be to be truly representative of the arc energy. Is it, therefore, advisable to contaminate this signal energy with the other? If a furnace control cannot respond to it properly as Mr. Cochran implies, then some form of magnification is required. But our furnace control can and does respond to it and does not require any magnification of the signal nor any distortion of the scale from some amplifier.

That which comes out of the secondary current transformers and that which comes out of a tap across the arc were called, respectively, current and voltage signals for years, as mentioned. No doubt, for convenience of identification, they shall continue to be so named. But when applied to arc-furnace practice, the user of the terms should first clearly define how he is using them. Mr. Cochran said the excitation requirements of the amplifying generators are low and permits the use of current transformers with the normal 5 ampere secondary. When the arc is normal they draw 5 amperes, of course, but when the arc varies they draw from zero to 10 amperes. These regulators also draw another zero to 10 amperes directly from the furnace bus. All this is used up only to regenerate a few amperes to drive the electrode motor. (The electrode motors on the new control use only 3.3 amperes.) Which of the excitation requirements are lower then? Which require smaller control transformers and smaller control rectifiers? Which will require more adjustment after initial installation? The control transformers and rectifiers in our control are liberally sized and only three sets are needed instead of six.

Suppose the current and voltage signals which the commentators refer to were just that. And suppose this voltage signal and this current signal are mixed, opposed, or used as they variously claim, would the current transformers choke the bus when the arc current is too high, or move the electrode only if the arc voltage is not right? Of course not! This control, just as any other, moves only the electrode to correct both the arc current and the arc voltage. Then why not use only the signal (across the arc) that truly represents the respective positions of the electrode? That is the only thing any of them move to control the arc energy.

Mr. Cochran stated that this was the time to evaluate the new control and then proceeded to describe only a furnace regulator in an attempt to prove whether the new control is actually advancing the art of electrode regulation. The new control is simply an electrode positioner energized directly by the only proper signal. It uses no furnace regulator. And, if electrode regulation is still an art, as he states, his entire discussion could only attempt to prove that the new control has or has not a chance to advance the art. The actual proof is in its use, whether it is an art or a science.

The new control was first tried behind closed doors on a single-phase arc furnace in our own research laboratory until all permutations of the new approach to the old problem were fully covered. This precaution was prompted by past experience, as many know. Only then, did we build a unit applicable to the small three-phase furnace at the University of Illinois, Navy Pier, Chicago. Professional men there were immeasurably helpful in its further development The Armour Research Foundation of the Illinois Institute of Technology, in Chicago also, selected and assembled the special testing equipment necessary to evaluate this extremely fast control.

The furnace at the pier was used only for foundry class instruction, so ample opportunity was provided to further study and develop the new control between class periods and during summer vacation. When this work was completed, a third unit was built for a furnace at the Kensington Steel Co. in Chicago. It was only then that an order was given to build a standard operator's panel for the new control and include in it a switch arranged so that the new control and the old control could be interchanged conveniently. The old control was a current contactor coupled to the air-counterbalanced, hydraulic, electrode drive; so interchangeability was made quite conveniently and the new control was given a thorough and rigid test under production conditions without the risk of a serious production interruption. Excellent cooperation and a growing intense interest in the new control was shown here too.

It was agreed that when we completed our work at the Navy Pier, the furnace there would be returned to its original state. But the users of the new control preferred it to the balanced-beam contactor coupled to the balanced cable drive; so the new control was put into permanent shape and left there for many to see in operation at this public institution.

It was understood also that when we completed the work at the Kensington Steel Co. and that if the new control could not do, in production, what it had already demonstrated it could do, then the new control would be removed and a rotating regulator would replace it (or augment it as Mr. Cochran suggests). The new control proved itself successful here too; so, it is now installed permanently here also and without the rotating regulator.

Mr. Cochran said, that the arc voltage is used as a reference with two specific purposes: (1) as an undervoltage signal to stop the electrode when it touches the metal in the furnace; and (2), to make the regulator on each phase completely independent of the other phases. First of all, that which is to be controlled cannot be a base of reference.

Certainly, a regulator that controls current only cannot stop an electrode from dipping. That is why an undervoltage limit switch was added to the old current contactor type regulator. Some people argued for years that this was all that was necessary to obtain perfect regulation.

The voltage tap does make one electrode operate independently of the others before any arc current flows, but how it makes each electrode completely independent he does not explain. Any change in the current of one electrode will change the current in one or both of the other electrodes. It has no other return. The same can be said about the arc voltage. Should not all electrodes try to keep the load balanced at all times? Unbalanced loads cause terrific strains and unnecessary heating in the electrical equipment. The new control positions each electrode completely independently when that is required. It positions each electrode with respect to the others too when that is required (even at the very next instant). It not only stops the electrode faster when the electrode touches the metal but immediately withdraws it from the metal too, whether or not arc current is flowing. This not only reduces surges (as shown in Figure 11) but it also reduces contamination of the metal with carbon from the electrodes. Our control will not permit the electrodes to dip into or lay down upon the charge as others are prone to do. It does all this inherently, without any added gadgets.

The new control uses the efficient balanced hydraulic electrode drive. The motors need not be even one hp and, therefore, are within the commutating ability range Mr. Cochran mentioned.

The motors operate continuously at substantial rpm where a very small change in speed results in great magnification through the hydraulic differential. The signal to the motors is strong because it has an abundance of energy behind it. (The short circuit capacity of the bus is relatively high.) So it does not have to be amplified. It is doubtful that any amplifying generator could generate as much energy or as fast as what a tap on the furnace bus can deliver without drooping.

The excitation requirements of the relatively small electrode motors used by this control are small and switching the motors on manual through the amplifying generators is not necessarily desirable. Failure of the amplifying generators often makes it impossible to operate the furnace on manual or automatic. Preventative maintenance on the generators also means shutdown. The furnace is preferably operable on manual without those machines.

There are no moving parts in the control except, of course, the electrode motors themselves. There are no limit switches, relays or contactors which move in any manner during automatic operation of the furnace with this new control.

The control utilizes hydraulic dynamic braking which is superior to electric dynamic braking. The hydraulic braking torque to stop the motor and the electrode is essentially constant. It was used on some furnaces for years because that of the electrical brake is drooping, approaching nothing as the speed of the motor slows. The hydraulic braking torque can be set to practically any predetermined value and can be supplemented with the electric dynamic braking torque too, if it were desired. It should be pointed out that electrical dynamic braking on the new control would mean something because its motors do their business at or near rated rpm and not at or near zero rpm where electrical dynamic braking means nothing.

It is interesting to note how Mr. Cochran developed another conclusion that it (the new control) requires a large amount of circuit reactance for the best performance. He starts with, "The regulator described by the author regulates arc voltage," moving the electrode up or down changes the arc voltage. What else does any arc-furnace control do?

The control receives a signal which is conveniently and accurately inversely proportional to the arc energy. This signal energy runs the electrode motor at a certain speed with reference to a fixed standard base speed. If the signal energy is too weak or too strong, the electrode moves up or down to decrease or increase the arc energy. It all works very well.

Voltage alone could not turn over any motor. But the electrode motors in the control do turn. How can this be explained? Every electric motor must have electrical energy input to produce mechanical energy output. Even a torque motor needs energy input to produce any torque. As soon as the motor starts or changes speed, the input must be changed to keep the torque constant. If this were not so, torque motors could be used for electrode counterbalance. But to keep the torque sufficiently constant would require another machine, and more gadgets to pace the movement without any lag. Anybody can build a complicated machine to do a simple job. The trick is to build a simple machine to do a complex job. This control is a simple machine doing the job quite well without extra machines and gadgets.

Mr. Cochran proceeds to say, regulating arc voltage is less desirable "because the amount of reactance in the supply circuit and in the furnace transformer primary and secondary circuits affects the characteristics of the regulator." The control is and should be affected by that reactance and directly too, because the arc is affected by it directly too. It is difficult to understand how Mr. Cochran can recognize that and still consider the voltage tap a good base of reference. Certainly, by his own statement, a regulator using it as a base of operations would have some difficulty hunting and chasing that base. Our control moves that point to where it belongs and keeps it there by operating from a base that stays put. Then, he proceeds to say, because of all this, it (the new control) works best when there is a large change in arc voltage for a change in arc length. There are times when there may not be any significant change in either the arc voltage or the arc current. Then there will be no significant change in arc energy and the electrode will not move. If it did, that would be undesirable electrode movement. If there is a significant change in either the arc voltage or the arc current or both, there will be a significant change in arc energy, of course. So the energy to the electrode motor will change and the electrode will move as it should. If it did not, that would be detrimental to good arc energy control.

From all this, he then arrives at the conclusion that the new control requires a larger amount of reactance. This is contrary to actual experience. Mr. Borrebach implies that the theory may have to be reoriented to agree with the results obtained in practice.

When the arc energy under any electrode changes from the preset desired value, that electrode must move to correct it and quickly. When the energy does not change, the energy to the electrode motor does not change. So nothing moves unnecessarily. However, it should be emphasized that with this control that

electrode which is the farthest off-balance will move the fastest to hold the floating ground of the secondary circuit in the center of the delta. And the other electrodes will help it get back to center quicker, even if the total load must be reduced to do it faster. It does this too, inherently, without any added equipment. Thus, it is more effective in holding the neutral point symmetrical in the delta, and thereby distributing the furnace load more evenly over the three phases to reduce transformer heating.

Speed of response in itself, one said, is not important. Neither is the combination of that and rate of electrode travel, which he said is important, unless the electrode also has a compatible acceleration to go with it. The new control gives the electrode all three. It is notable that the electrode must have all these three characteristics and not just a part of the control.

The degree of overshoot of an electrode increases with the speed of the electrode, but diminishes directly with the speed of response and acceleration and deceleration. Electrode speeds, therefore, cannot be just arbitrarily selected. All three characteristics must be of proper value for best performance.

Mr. Cochran said this control requires a 100 per cent change in signal to achieve a 100 per cent electrode speed. Thus, he concludes that it takes a long time to correct small errors. This again is contrary to actual experience. Is it not a question of degree? What is 100 per cent electrode speed? Is it the highest speed a control can impart to an electrode in seconds? That would mean nothing to good arc energy control. Electrode speeds reached within a few hundredths of a second are the criterion. Here again, he disassociates two components (speed and acceleration) and arrives at an equivocal conclusion.

The control is not as plagued with energy losses and inertia. Its maximas have not yet been reached. Electrode speeds of over 20 fpm on impulse demand with compatible accelerations are already an accomplished fact with this control in practice, as shown in Figure 11. In tests, the figure is considerably higher. So, with this control, it is only a choice of the top speed and acceleration desired for the full signal, to obtain the desired proportional speeds and acceleration for the proportional signals. There is no need here for any added distorted scales. The control, inherently, has its own.

Operating experience shows that any change in the signal which this control does not correct quickly is so small that it will be exceptionally difficult to find. It has been demonstrated that even a 7-watt change in the signal actually caused a reversal of the electrode. (Note: The value is in watts, energy, not volts.)

Mr. Cochran states that the new control has a number of points that are different. He refers to all of them as deficiencies though. But, he insists that all of them can be overcome by the addition of the rotating regulator to this control. The one difference, nonreversing motors, which cannot be successfully attacked even before the laity, he allows to be retained.

It is quite true that we can so employ the rotating regulator with or without the so-called current signal and obtain what some consider excellent operating results. But excellent operating results are being obtained without it. There may be conditions under which we may wish to use a rotary generator with it, but those, when and if encountered, will have to be sufficiently severe to justify the added cost, and complexity, and drop in response.

Many of the comments made are largely based upon electrical theory. It should be pointed out that users of the amplifying generators who have investigated performance carefully, have found "dead" spots of substantial extent. While it may not be fair to say this is inherent in the regulator part of the control, it is nevertheless a characteristic encountered by operators in everyday practice. The extent of these "dead" spots appear to be proportional to the weak spots . . . . the reversing motors, especially as they become larger on larger furnaces. They just simply cannot respond to even the delayed signal from the generators as rapidly or as accurately as the generators can develop the signal.

In his closing remarks, Mr. Cochran states that the author's suggestion will not work on his amplifying generator. Maybe it will not work on that machine; but the author believes it too is sensitive enough to respond to this arc energy signal. A logical analysis showed that it should work. It was tried on a competitive machine. It did work and a curiosity was satisfied. There was no further interest in it because an arrangement eliminating the machine entirely worked better. Certainly no harm can be done by reporting an experience. Others may wish to satisfy their curiosity too. They may find it expedient in an emergency too, if a furnace is down because something broke down (a current transformer or a rectifier or a coil or a resistor tube, etc.), and a replacement is not immediately available.

Mr. Hanff states that there are a number of statements and claims in the paper with which other manufacturers and furnace operators may not agree. He says that he does not understand how the new control can possibly reduce the magnitude of a surge. The higher speed of response of the control, he says, can only shorten the duration of the surge.

When the duration of a surge is shortened, the magnitude of the surge is reduced. The author defines magnitude of a surge as the product of its amplitude and its duration. This distinction should be made; otherwise, how controls do or do not reduce the amplitude, duration or magnitude of a surge cannot be clearly understood. It is not important what these functions are called as long as everyone is talking about the same thing.

Mr. Hanff states further that the instantaneous current is determined by the applied voltage and the total impedance in the circuit at the moment of contact (between electrode and the charge). This current, he says, will persist for several cycles or until the electrode moves to increase the arc resistance. Then, how, in 0.05 sec or 3 cycles, he concludes, can the magnitude of the surges be reduced with this control? Here again, the moment of contact needs clarification to avoid any possibility of delusion.

Impedance is the sum (vector sum to be exact) of resistance and reactance. At the very first moment of contact, the instantaneous current which starts to flow is impeded only by the resistance, before the reactance can produce any significant impedance to current flow. This is not difficult to understand if one stops for a moment to analyze how a reactor works. It does not

work instantaneously either. Current must first flow through it before it knows anything. Then it builds up a magnetic field from this current to induce a counterforce to react against the current. That occurs, effectively, at another later moment, obviously. But the resistance becomes effective at the very first moment because the current "bumps" into it the instant the two meet. This develops heat (the other does not) and if this occurs inside of the furnace, the furnace is in business at the very first moment.

Does the new control permit the furnace to get into business at that very first moment? It does, inherently, without any added gadgets. In fact, it seems that this control even anticipates the instantaneous current flow. It starts the electrode back upward as soon as the contact is made, whether the current started to flow or not. It does not permit the electrode to go down and lay down upon the charge and wait for something to happen. When it happens, it is too late to stop it.

The new control "plays" the electrode lightly upon the charge until that instantaneous current starts to flow. At that instant, the closest bits of metal in the charge and the electrode sputter away. Immediately the added arc resistance, Mr. Hanff mentioned, is established to reduce the amplitude of the surge, even before the control reacted to it.

With the amplitude reduced and the duration reduced, the product of these two, which is the magnitude, is obviously considerably reduced. When the magnitude (energy) of the surge is small enough, the energy stored in the capacitance of the system will "feed" the surge without the usual appreciable line droop (high-line voltage drop). This desirable inherent characteristic of the control is explained in the paper and need not be repeated here.

Some old installations have reactors with taps from zero up to as much as 50 per cent. Some of the newer installations with better control do not use even half that much on smaller furnaces and on higher voltages and lower current values where the effective reactance from this nominal reactance is less. All the facts must be given.

Mr. Hanff also states that the new control is only voltage-sensitive and not sensitive to the kilowatts in the furnace. The proof he offers is the fact that "many years ago, it was found that the combination of voltage and current elements improved the regulation." That is true because they started with the current "element" first and found it inadequate. Mr. Cochran, on the other hand, says that the addition of the voltage element only prevents the electrode from dipping and that the current "element" is the all important governing influence. Who is right or wrong is shown by the new control, which is doing the job and quite well.

Mr. Hanff mentions minor fluctuations. What minor fluctuations can the heavy cable winch drives sense? How long would clanking gears and worms last, if they did try to correct them all? How long would reversing motors last, if the reversing currents were continually and rapidly pumped into them? And what are minor fluctuations? There seems to be a difference of opinion in the evaluation of what is a minor and what is a major fluctuation, depending upon who and what is affected. The real question is: "Can the control do it practically or at all?" It can be always dampened, but the converse is not true.

The modern rotary regulators, when properly adjusted, Mr. Hanff says, are giving excellent results in a great many installations. Those regulators cannot produce any results from a furnace without the electrode drive. And the efficiency of that drive should be at least somewhere near equal to the efficiency of those regulators.

Mr. Hanff avoids mention of any electrode drive in his closing remarks where he states, "Many operators and maintenance men will still express a preference for complete electrical operation of electrode mechanism over the hydraulic system." Where is there a "complete electrical operation of electrode mechanism"? Do not all arc furnaces have some sort of an electrode drive, mechanical or hydraulic? Then why does he not compare them? Does he not use hydraulics for raising the roof for smoother operation, and better control? Does he not use hydraulics for swinging the roof and for tilting the furnace for the same reasons? Then why should not hydraulics be used for the business end of the furnace where smoothness of operation and control is most essential?

It is true that some will still express a preference for the mechanical instead of the hydraulic drive. And this preference, no doubt, is based upon some real past experience. But hydraulic brakes on automobiles have had their experiences. And who, today, drives an automobile without hydraulic brakes? Why do hydraulics survive these experiences and eventually the expressed opposition? Because they are continually improved and because some jobs cannot be done satisfactorily without them. The new control is such an

Figure 6 — Servo-units shown are used on furnace control shown in Figure 5.

improvement, and control of the arc cannot be done properly with cumbersome mechanical drives.

The response of the rotating type control is entirely adequate for the electro-mechanical winch type electrode mechanism which Mr. Lawrence describes. The increase in electrode speed to 50 in. per minute and the use of high power high voltage transformers are both steps in the right direction. Precise control of both the arc current and arc voltage is necessary for proper control of the arc because the arc energy (heat) is a function of the voltage across the arc and the current in it (which is in phase with that voltage).

It should be emphasized that the relatively few electrical and hydraulic parts used in the new control are designed into an integrated unit, matched to work together with equal efficiency to produce a highly satisfactory end result. Ordinarily, the electrical manufacturer has no control over the type of connection the furnace builder establishes between the electrode motor and the electrode. There is also a tendency for the electrical manufacturer to build one compromised design for all types of electrode positioners whether hydraulic or mechanical, balanced or unbalanced. Each has its own inherent characteristics and needs different treatment. The design of our control is completely and singularly under one authority and one responsibility.

Figure 6 shows the servo units of the control at the Kensington Steel Co. Each unit is for one phase and consists of the two motors M_1 and M_2, pumps P_1 and P_2 and the valve cluster shown schematically in Figure 5. The conduits above contain the motor leads going to the operator's panel. The two large horizontal pipes are the intake and return from the air-oil tank. The smaller horizontal pipe is connected to the cylinder which raises and lowers the electrode.

Figure 7 shows the standard operator's panel arranged for convenient interchangeability with the old panel. The lights, meters, rheostats, and switches are of the same type and arrangement as found on any other standard operator's panel.

Figure 8 shows the rear view of the operator's panel. The meters shown are used here only for testing purposes and the switch is used for interchanging the new and old controls.

Figure 9 shows the rear door of the operator's panel open. The large meter shown temporarily connected with jumpers was being used for collecting operating data. The three small tap transformers below it and the three tap resistors at the top are a part of the furnace transformer tap changing mechanism. The six small resistor tubes are used for manual operation of the electrode motors. Note there is no equipment here for the automatic operation of the control.

In Figure 10, the front door of the panel is open to show that there are no moving parts here either used during automatic operation of the control. From left to right, starting at the top are: a 220-volt, a-c auxiliary service undervoltage relay; four tap changer position relays; and another meter used for testing. (This is an ammeter in the control ground circuit.) The next two rows of relays are used for only manual operation of the electrode motors. Since the current used by these motors is considerably less than four amperes, some will question the need for even these pieces of equipment. The next row of three relays, one for each phase, are used only for turning the automatic control on or

Figure 7 — Arc furnace control panel was arranged for convenient interchangeability with the old control.

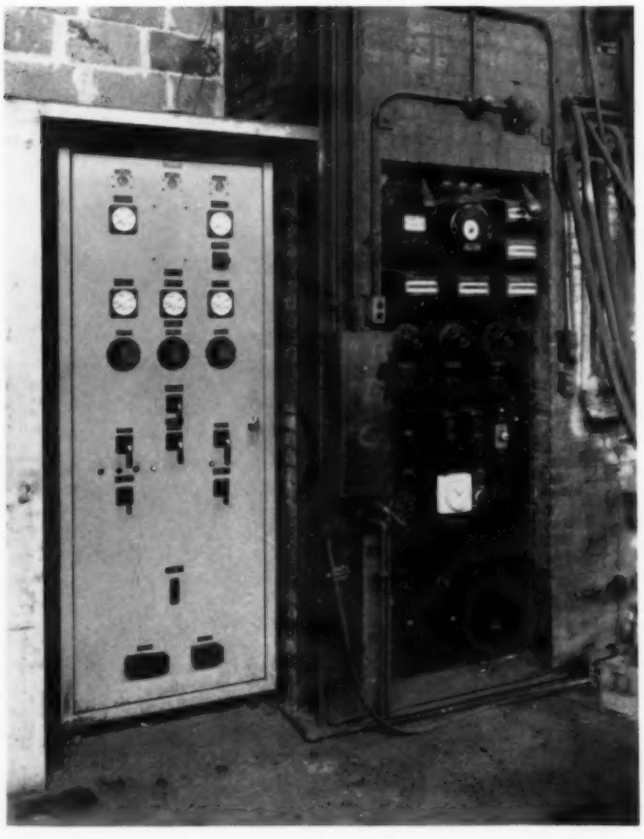
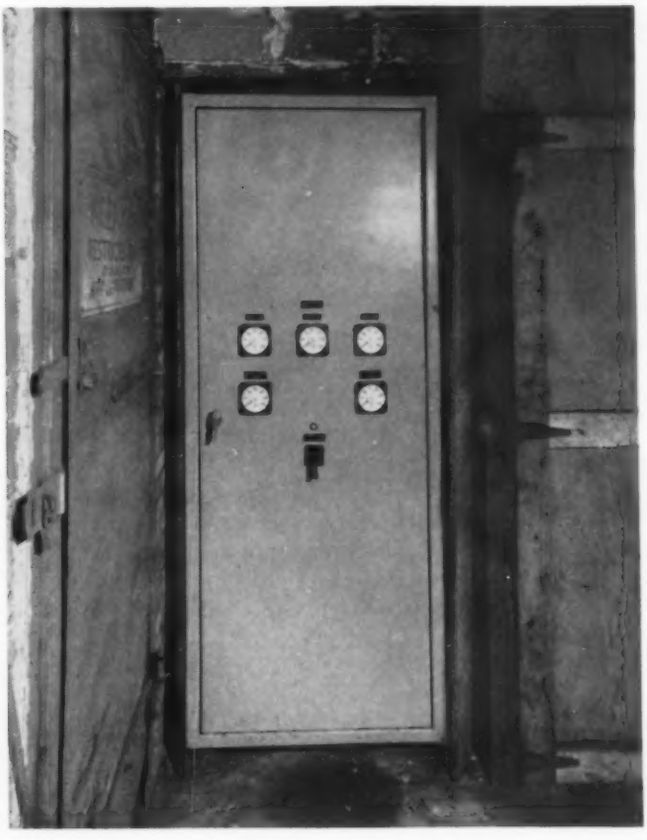


Figure 8 — Rear view of control panel shows meters used for testing purposes as well as switch for interchanging new and old controls.



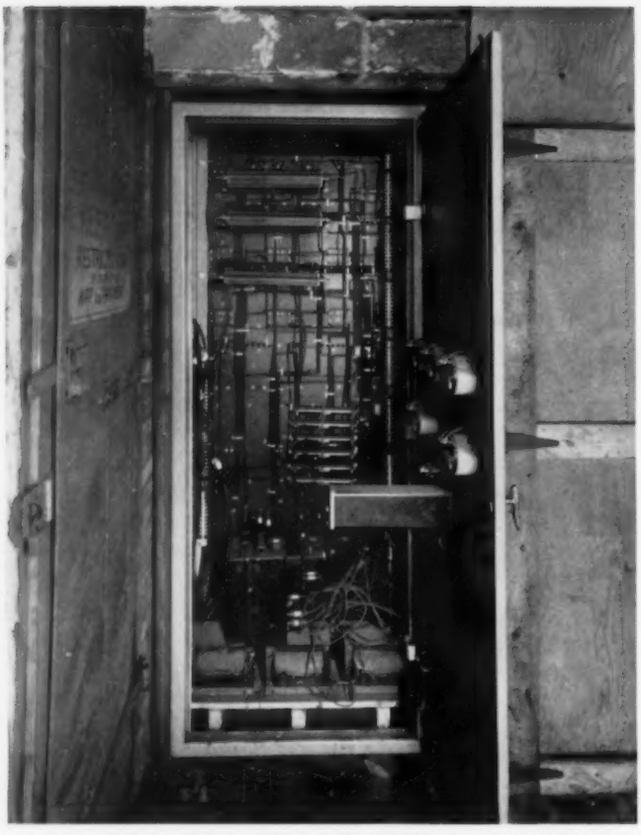


Figure 9 — Furnace control panel is shown with rear door open.

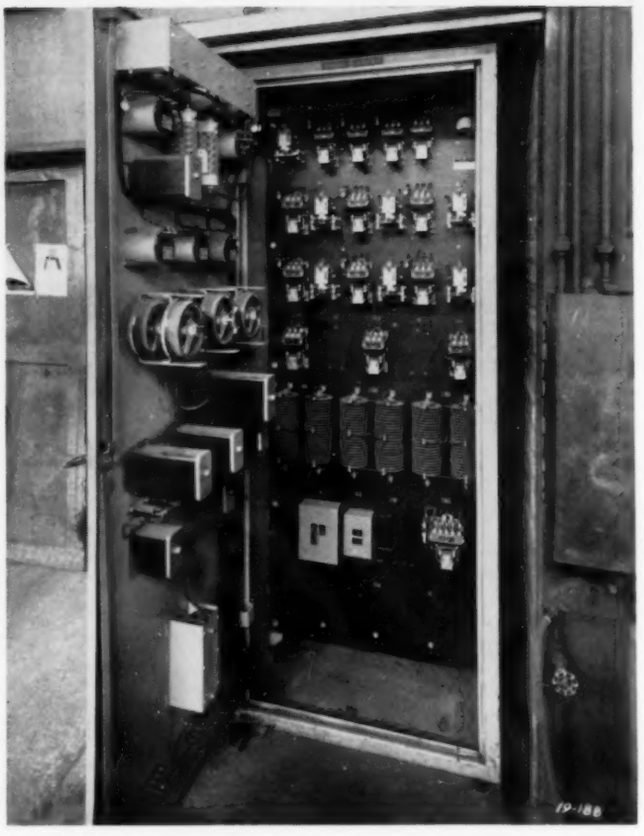


Figure 10 — Control panel is shown with front door open.

off. (The need for these is questioned also.) Next, are the rectifiers, one full wave set for each phase, shown schematically in Figure 5. Note there is only one full wave set per phase. On the bottom is a circuit breaker used for protection of the control circuits. Next to it, is another circuit breaker used with the undervoltage relay, already mentioned. Breakers are used in the new control instead of fuses. The last relay is used with the change-over switch for interchanging the new control with the old.

This control panel and the servo-units is all that there is to the control. It is quite obvious that where all the testing and switching equipment, along with its wiring, is removed, the panel is simple enough for any furnace man to understand without a special course in arc-furnace circuits and equipment.

Figure 11 shows a typical oscillograph of the control in action. These oscillographs were made by the Armour Research Foundation, while they were evaluating the control at the University of Illinois, to see if it is actually advancing the art of electrode regulation. The whole chart from one end to the other represents only 670 hundredths of a second (less than 7 seconds).

Before the furnace was started, one electrode was lowered to about 1 in. above the scrap, the second higher, and the third still higher. The object was to have each contact the scrap with a substantial interval of time in between each contact.

There are four traces on the chart. The top one is the voltage applied to the armature of the electrode motor (M_1 in Figure 5). Below that is the arc current and below that is the arc voltage. The fourth trace which traverses the others is the magnified movement of the first electrode, the one placed nearest the charge. When that trace goes upward, the electrode was traveling downward and vice-versa.

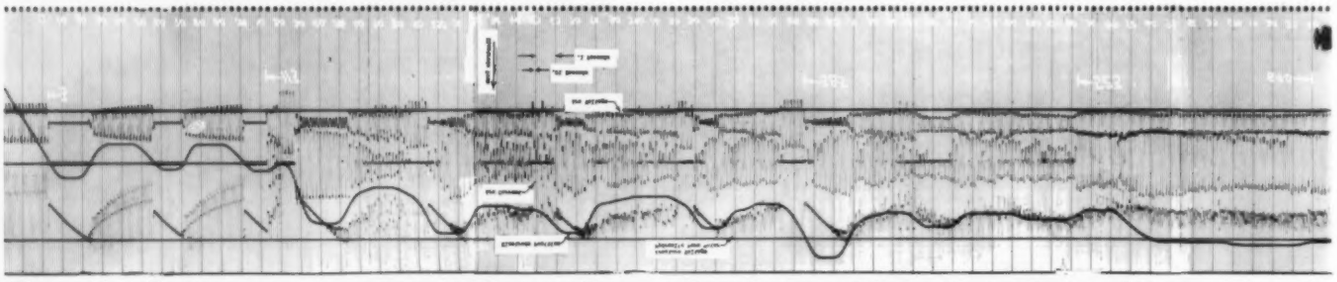


Figure 11 — Oscillograph was made by the Armour Research Foundation and shows the beginning of furnace operation.

The control was started and the electrodes were energized. The chart starts showing the electrode going down at the rate of 128 in. per minute at point on chart marked zero seconds. At 0.03 sec later, the electrode made electrical contact with the scrap. The potential between the electrode and the scrap dropped to almost nothing and only a feeble exciting arc current started to flow since neither of the other electrodes had yet

contacted the scrap. At this same instant, the electrode motor started to generate a back electro-motive force to slow down the electrode.

The electrode started to slow down at 0.06 sec or 0.03 sec later and completely stopped at 0.10 sec or 0.07 sec after the electrode made contact with the charge. The electrode overtravelled and compressed the points of contact only 0.099 in. The load on the cylinder dropped and valve V_4 was already completely opened to prevent any appreciable weight shifting to the electrode.

Motor M_1, while slowing down, passed the speed of motor M_2, valve V_4 started to close and at point 0.18 the electrode started upward reaching a speed of 144 in. per min at 0.24 where contact with the scrap was broken. The electrode started to slow down at 0.25 and stopped completely at 0.34 where check valve V_4 again opened to prevent the cylinder from pulling away from the electrode support in this case too. (If the cylinder were attached rigidly to the support and valve V_4 were not used, the electrode and support would be jerked down. Air would be sucked into the cylinder around the packing also. An undue overload on motor M_1 would result too. This is all prevented, and simply.)

Valve V_4 closes and the electrode starts down again at 0.46. The cycle is repeated continually until one of the other electrodes also makes contact with the scrap, as at point 1.13.

Here, the first electrode compressed the points of contact only 0.047 in. when the other electrode came close enough to the charge for the voltage to push the instantaneous arc current across the gap. The control, practically anticipating this, started upward to draw it out. Bits of metal and electrode high spots sputtered out to further draw out the arc gap (and increase the arc resistance). Note how that instantaneous arc current was pulled down (by this arc resistance and the added arc resistance) even below the normal current shown at the end of the chart.

As soon as the instantaneous surge was cut off completely at 1.20, the electrode started down into the crater (0.104 in. deep, formed by the first impulse) at a speed of 253 in. per min to restrike the arc at 1.27. This top speed was reached in only 0.06 sec with an average rate of acceleration (from start to top speed) of 6 fps squared.

From this point on, the second electrode helped the first to keep the current surge down to not much more than normal at its peak for three cycles only (point 1.30). Then the third electrode made contact and the three worked together to keep the current at or below normal. At 6.40, or 5¼ sec after current started to flow, all three electrodes pulled the normal load evenly.

The rest of the 50 feet of chart was too monotonous to reprint. The electrode trace gradually went off the chart. The other traces remained as constant as at the end of this piece of the chart. If the electrodes, at the start of the operation, were placed above the scrap evenly instead of purposely staggered, that 5¼ sec would have been considerably reduced. It was done merely to make the action of each electrode clearly defined on the chart.

This control is an integral part also of our whole furnace, designed, made, sold, and installed without any division of responsibility. The control is readily adaptable to any furnace that has an electrode positioning cylinder or to which such a cylinder can be applied. Its basic principle of operation is not limited to hydraulic application only or to only arc furnace applications. Many had already recognized how it can be used to improve other operations.

No one is taking any credit for the multitude of unique characteristics in this new control. They just happen to be there inherently, and fortunately favorably. But, the author subscribes to the principle, "If a design is basically sound, it will have inherently all the characteristics required for its purpose and will not require any added devices to embellish it."

1955 AISE

ANNUAL CONVENTION

SEPTEMBER 26, 27, 28, 29

HOTEL SHERMAN CHICAGO, ILL.

PROGRAM

ASSOCIATION OF IRON AND STEEL ENGINEERS

WESTERN MEETING

ST. FRANCIS HOTEL
SAN FRANCISCO, CALIFORNIA

March 21, 22, 23, 1955

MONDAY, MARCH 21

8:30 am—REGISTRATION—Mezzanine Floor

9:00 am—TECHNICAL SESSION—Colonial Room

Chairmen: W. A. Marshall, Works Engineer, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

N. L. Bock, Chief Engineer, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

"Control Systems Utilizing Non-Contact Gages," by W. E. Van Horne, Assistant to the Executive Vice President, Industrial Nucleonics Corp., Columbus, Ohio

"Reel Control Systems for Mills and Processing Lines," by A. J. Winchester, Jr., Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Application of Rotary Hearth Furnace for Heating Plate Mill Slabs," by F. C. Schoen, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

"Reversing Hot Strip Mill . . . Its Place in the Steel Production Facilities," by David Lyle, Vice President, Continental Foundry and Machine Co., Pittsburgh, Pa.

2:00 pm—TECHNICAL SESSION—Colonial Room

Chairmen: E. F. Donatic, Assistant General Superintendent Maintenance, Kaiser Steel Corp., Fontana, Calif.

E. C. Thomas, Works Manager, Pacific States Steel Corp., Niles, Calif.

"The Hot Extrusion of Metals," by G. A. Moudry, Chief Metallurgist, Harvey Machine Co., Inc., Torrance, Calif.

"C. F. and I. 3-Strand High Speed Rod Mill," by V. W. Johnson, Superintendent, Rolling Mills and Finishing, Colorado Fuel and Iron Corp., Pueblo Plant, Pueblo, Colo.

"First Cost vs Maintenance Cost of EOT Cranes," by William A. Perry, Assistant General Superintendent—Service, Inland Steel Co., East Chicago, Ind.

"Normalizing and Annealing of Steel Products," by James MacGregor, Board Chairman, York-Gillespie Manufacturing Co., Pittsburgh, Pa.

TUESDAY, MARCH 22

9:00 am—TECHNICAL SESSION—Colonial Room

Chairmen: G. B. McMeans, Vice President Charge of Operations, Kaiser Steel Corp., Oakland, Calif.

R. J. Tremblay, General Superintendent, Bethlehem Pacific Coast Steel Corp., Los Angeles, Calif.

"Continuous Casting at Atlas Steels Ltd.," by John F. Black, Manager, Continuous Casting Section, Freyn Dept., and F. W. Rys, Assistant Manager, Freyn Dept., Koppers Co., Inc., Pittsburgh, Pa.

"Electronics and Magnetic Amplifiers and Their Application," by John W. Fox, Manager, Applied Engineering, The Clark Controller Co., Cleveland, Ohio

"Report on Arc Furnace Future," by Frank Nicholson, Arc Furnace Engineer, Swindell-Dressler Corp., Pittsburgh, Pa.

"Special Problems of Waste Disposal in the Steel Industry," by T. F. Barnhart, Senior Process Engineer, Chemical Plants Div., Blaw-Knox Co., Pittsburgh, Pa.

hotel reservations

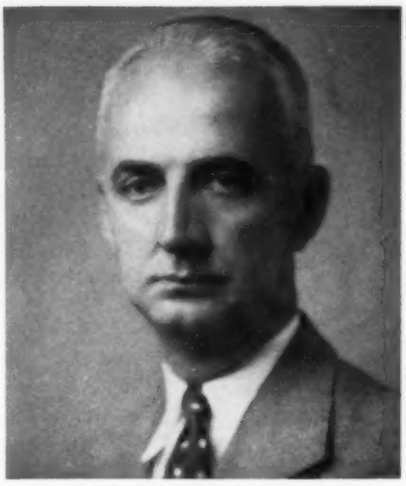
Write direct for hotel reservations to St. Francis Hotel, Union Square, San Francisco 19, Calif., giving time of arrival and type of accommodations desired. Reservations should state that they are for AISE Western meeting.

transportation

Individuals or groups desiring assistance in planning their trip should get in touch with the office of American Express Co. in their respective cities or with any local travel agency.

plant visits

Members of the AISE who wish to visit steel plants when attending this meeting should make arrangements for such visits directly with the plants involved.



W. A. MARSHALL

N. L. BOCK

E. F. DONATIC

2:00 pm—TECHNICAL SESSION—Colonial Room

Chairmen: Ruben Finkelstein, Vice President, Southwest Steel Rolling Mills, Los Angeles, Calif.

W. F. Pruden, Chief Engineer, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

"The Scope of the Furnace Fume Control Problem," by H. L. Richardson, District Manager, Research-Cottrell, Inc., Pittsburgh, Pa.

"Methods to Increase Open Hearth Production," by G. W. Teskey, Jr., Open Hearth Superintendent and W. L. Murphy, Fuel Engineer, Bethlehem Pacific Coast Steel Corp., South San Francisco, Calif.

"Ingot Mold Manufacture at Kaiser Steel," by Jack B. Klukkert, Assistant Superintendent, Foundry, Kaiser Steel Corp., Fontana, Calif.

"Ventilation of Steel Mill Electric Equipment," by S. L. Jameson, Construction Engineering Section, General Electric Co., Schenectady, N. Y.

7:00 pm—INFORMAL STAG DINNER—Colonial Room

Speaker, Laurence S. Dahl, Vice President—Charge of Operations, Columbia-Geneva Steel Div., United States Steel Corp., San Francisco, Calif.

E. C. THOMAS

WEDNESDAY, MARCH 23

Inspection trip to the Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif. Buses will leave St. Francis Hotel at 8:30 am.

G. B. McMEANS

R. J. TREMBLAY

W. F. PRUDEN

Abstracts of Technical Papers

to be presented at technical sessions of

AISE WESTERN MEETING

St. Francis Hotel San Francisco, California

March 21, 22, 23, 1955

"CONTROL SYSTEMS UTILIZING NON-CONTRACT GAGES"

by W. E. VAN HORNE, Assistant to the Executive Vice president, Industrial Nucleonics Corp., Columbus, Ohio

W. E. VAN HORNE

▲ A production control system should be considered as an integrated whole, including equipment and procedures for performing five basic functions: 1. measuring, 2. controlling, 3. monitoring, 4. recording, and 5. classifying.

The measuring equipment is the foundation upon which the entire system is built. Accuracy, dependability and speed of response are the necessary criteria for the measuring system. For a control system to be truly automatic, the measuring gage must be truly automatic. It must be capable of maintaining permanent calibration independent of operating conditions.

The controlling equipment or procedures must take the information given by the measuring gage and act upon it. If the product deviates from the desired specification, the controller must readjust the process machinery to bring it back in line.

The monitoring function must be performed to insure the proper operation of the gage and controller. The monitors should automatically shut off the equipment and sound an alarm in case of any kind of failure.

Production records must be kept in such form as to be of use to all departments of the company. Hence, a mechanized control system should include data-reduction equipment which totalizes on counter dials or even directly on punched cards.

A classifying function is necessary to insure that no out-of-tolerance product will be shipped to a customer.

Non-contact radiation gages and associated equipment are in use automatically performing some or all of these functions on the manufacture of cold-rolled strip, hot-rolled strip, galvanized strip, and electrolytic tin plate. Tandem cold reduction mills are being automatically controlled by a combination of first-stand screw actuation and finishing-stand speed adjustment. Reversing cold mills are being controlled completely by screws. The output of hot-strip mills, continuous galvanizing lines, and electrolytic tinning lines is being measured, though not yet automatically controlled, by non-contact gages. Data-reduction equipment is available for automatically totalizing all of these measurements. Finally, automatic classifying and re-classifying equipment is in use, actuated by non-contact gages measuring either a continuous strip ahead of a shear or individual sheets on a conveyor.

"REEL CONTROL SYSTEMS FOR MILLS AND PROCESSING LINES"

by A. J. WINCHESTER, JR., Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

A. J. WINCHESTER

▲ SINCE reels are extensively used on both hot and cold mills in the metal working industry, reel control is important. This is true even more so today because of the demand for and increased use of higher speeds for rolling mills. A large portion of the industry output consists of thin material which can be coiled without permanent deformation. The addition of reels to mills handling this type of material greatly increases efficiency of operation, and they are now almost universally used wherever possible.

A basic requirement on reels is that the strip tension must remain essentially constant throughout coil build-up. Coil build-up of three to one is normal, and four to one and five to one are occasionally used. Uneven tension during coil build-up results in a coil with irregular edges; such a coil is difficult to handle, the edges are easily damaged, and it takes up more space. The tension must always be low enough to prevent breaking the strip and high enough to prevent resiliency of the material from unwinding the coil.

Originally, reels operated at maximum strip speeds of one to two hundred fpm. Now, some operate at speeds as high as six and seven thousand fpm.

Footnote: Abstracts of some papers were not available in time for publication.

This paper reviews the performance requirements of modern reel control systems and discusses several typical schemes.

"APPLICATION OF ROTARY HEARTH FURNACE FOR HEATING PLATE MILL SLABS"

by F. C. SCHOEN, Chief Engineer, Alan Wood Steel Co., Conshohocken, Pa.

F. C. SCHOEN

▲ THE modernization program of Alan Wood Steel Co.'s 84-in. plate mill included replacement of existing heating facilities consisting of six batch-type furnaces. An intensive study was made of various types of continuous furnaces and rotary furnaces, with particular reference to their ability to handle a wide range of width, thickness and length of slabs. The study also included material handling, space limitations, manpower requirements, and ease of installation with minimum shut-down of existing production facilities, as well as, estimates of cost for complete heating and material handling installation.

The final arrangement of equipment, consisting of depiler, cold slab conveyor, charging and discharging mechanism and rotary furnace, is described (with slides) with particular emphasis on those items peculiar to the needs of the Alan Wood installation. During the construction of foundations and erection of 90 per cent of the equipment, the loss of production facilities was held to less than 25 per cent. The final installation then took place during a three-week period when the entire department was out of operation.

A number of problems arose after the start of the furnace operation which required changes in scheduling methods as well as mechanical changes and adjustments in order to fully realize the capacities of the new equipment. Present results of continuous heating with rotary hearth furnace are reaching expectations, and few if any details of the original planning would be changed for future installation.

"THE HOT EXTRUSION OF METALS"

by G. A. MOUDRY, Chief Metallurgist, Harvey Machine Co., Inc., Torrance, Calif.

G. A. MOUDRY

▲ AMONG all of the metal working processes, the hot extrusion of metals is unique and stands by itself as one of the most versatile of them all. In one operation, a cast billet having a typical cast alloy structure can be transformed into a wrought structural shape with complicated cross section, and with length a hundred times that of the original billet.

The mechanical properties of extruded material are usually superior to those resulting from other hot metal working processes. This is partially because work imparted to the metal is uniform, and the billet is literally "turned inside out."

Alloys of metals such as aluminum, copper and magnesium have been extruded for years and their methods of fabrication are no longer strange to the metal working industry. However, for aluminum in particular, larger extrusion presses, new applications and advanced alloys are providing accelerating impetus to the extrusion industry.

New-comers, such as strong alloys of titanium and steel, loom on the horizon as potential materials for extrusion of structural components. Titanium alloys, particularly, are notoriously bad actors in any working method. However, extrusion offers economic and metallurgical advantages that assure its application in the fabricating of these new alloys. Furthermore, some configurations required by structural designers can be produced only by hot extrusion, because of their complexity.

"C. F. AND I. 3-STRAND HIGH SPEED ROD MILL"

by V. W. JOHNSON, Superintendent, Rolling Mills and Finishing, Colorado Fuel and Iron Corp., Pueblo Plant, Pueblo, Colo.

V. W. JOHNSON

▲ THE Colorado Fuel & Iron Corp. at Minnequa Works, Pueblo, Colo., put into operation on August 29, 1949, a new, modern, three-strand, high speed, continuous rod mill. This new mill replaces the old hand looping Garrett mill that had been in continuous operation since March, 1903.

This rod mill is a completely new installation, incorporating all the latest ideas and methods, such as; workmans safety devices throughout the mill; automatic equipment to control and regulate the gas, air and furnace pressures on both the heating and holding furnaces; automatic warning systems of lights and sirens on oil and water pump systems; electronically controlled air pumps for rod switching; new and improved pass design changes for better quality rods. Numerous other applications of the latest mechanical and electrical ideas of the best known designs were incorporated in this installation to make it the last word in modern ideas and designs.

The main building for this mill is 475 ft long by 90 ft wide, considerably larger than is required for a conventional rod mill. There are two furnaces, table roller lines and 27 roll stands in this building, in fact, it can be classified as two mills operating simultaneously as one mill, producing a $\frac{7}{32}$-in. rod from a $4\frac{3}{8}$-in. billet in 27 passes. Actually it is a 4-stand billet mill ahead of a conventional rod mill with a holding or heat restoring furnace between the mills. This is unique compared with conventional designs, and can be classified as a custom built mill, tailored to fit into our other

plant facilities. The reason for this unique design, was we did not have facilities for producing the required 2½-in. billet economically, not having a billet mill. The rail mill, due to railroad demands, did not have sufficient mill time to roll the required tonnages of 2½-in. billets. However, we did have sufficient mill time on the rail mill to produce the required tonnages of 4⅜-in. billets to meet all of rod mill requirements. This larger billet size lends itself to quick changes with a minimum amount of delay.

The new rod mill when rolling the smaller rod sizes, finishing in roll stand 22 at normal speeds of about 5000 fpm, produces high quality rods in coils or bundle weights of approximately 700 lb. With normal operation, three strands being rolled simultaneously, the 8-hr record on this mill produced 449 net tons of $^{7}/_{32}$-in. rod, equal to 56.12 tons per hour, or 178 mphr, or almost 3 miles per minute.

"CONTINUOUS CASTING AT ATLAS STEELS LTD."

by JOHN F. BLACK, Manager, Continuous Casting Section, Freyn Dept., and F. W. RYS, Assistant Manager, Freyn Dept. Koppers Co., Inc., Pittsburgh, Pa.

▲ THIS paper is of interest to steel mill operators and engineers because it describes the first commercial installation of a continuous casting machine for steel on this continent. A moving picture will also show actual operation of the machine which finally takes its place as an advanced development in the art of steelmaking.

JOHN F. BLACK

The equipment can function as an auxiliary in the large steel plant. It is no longer limited by casting sizes, and present techniques make it a feasible and proven method for casting large slabs. Similar techniques and improvements in cooling facilities make the machine an instrument for high speed casting of billets down to two inches square.

F. W. RYS

It provides for the small producer, flexible billet making capacity at relatively low capital cost and moderate operating expense. It is equally adaptable to the casting of carbon or alloy steels over a wide range of analyses, and the process covers almost unlimited possibilities in the modern steel mill.

"REPORT ON ARC FURNACE FUTURE"

by FRANK NICHOLSON, Arc Furnace Engineer, Swindell-Dressler Corp., Pittsburgh, Pa.

▲ ADVANCES made over the past seven to ten years in the field of metallurgy, combined with electrical and mechanical improvements, have given in the electric furnace, a steel producing tool that affords an availability rate of 95 per cent, and boasts an average yield of 92 per cent. These well established rates of availability and yield, coupled with its inherent characteristics of flexibility, make the electric arc furnace the most economical cold melting steel producing component available in the industry today. It is noted that the open hearth, currently offering lower "costs above" but requiring greater "metallic" expenditure per ton poured, compares favorably on these two cost factors with the electric furnace, since the electric furnace process incurs about the same dollar costs, in reverse proportion.

FRANK NICHOLSON

The margin of difference, currently favoring the electric furnace by approximately $4.00 per ton, lies in the capitalization requirements for each process.

A consideration of power rates, showing the steady decline in costs as a result of increased capacity and utilization of generating equipment enables us to visualize even greater savings in the electric furnace process in the years to come.

Some of the general fields in which improvements have been made to enhance arc furnace steelmaking are in mechanical design, electrical equipment, fume collection, refractories, electrodes, plant layout and metallurgical developments.

The mechanical improvements include such features as:

1. Improved top charge design (exclusive to arc furnaces).
2. Deeper shells to accommodate lighter scrap.
3. Scrap handling and charging equipment.
4. Electro-mechanical design to reduce power.
5. Remote controlled electrode holders.
6. Oversized roof rings and water cooled shell brims.

With regard to electrical advances, there have been great strides made to improve arc furnace operation, and there are now available such modern components as:

1. Rotating, variable voltage electrode regulators, insuring fast accurate electric positioning and requiring minimum attention.
2. Air circuit breakers designed for highly repetitive furnace switching duty and primary fault protection.
3. Compact, rugged furnace transformers, offering higher secondary voltage taps to assure peak power input and reduce melt time.
4. Devices to minimize voltage fluctuations into improved power factor.
5. Demand limiting equipment to control power costs.

In addition to the success of the electric arc furnace in the straight production of carbon and alloy steels, the introduction of blown hot metal, induction stirring and continuous casting have increased the fields of utilization of this modern, high-powered steel melting facility.

At the close of 1953 it is noted that electric furnaces were responsible for approximately 7 per cent of the

country's steel production, which is rated at a total capacity of 120,000,000 tons. Based on projected figures for the next twenty-year period, the electric furnace is expected to reach a total capacity of 40,000,000 tons, or 25 per cent of the nation's anticipated total capacity. These figures, therefore, reflecting a 33 per cent increase in the nation's steelmaking capacity during the next twenty years, show a tenfold increase in electric furnace capacity, amounting to $900,000,000,000 in capital expenditures, over the same period.

"SPECIAL PROBLEMS OF WASTE DISPOSAL IN THE STEEL INDUSTRY"

by T. F. BARNHART, Senior Process Engineer, Chemical Plants Div., Blaw-Knox Co., Pittsburgh, Pa.

T. F. BARNHART

▲ THIS paper concerns itself with the treatment of waste pickle liquor by a new process, whose basic chemistry was discovered by Mr. Othmar Ruthner of Vienna, Austria. Since that time, our company has contracted for the patent rights to the process and has spent several years doing extensive development work, including laboratory work, equipment testing, and process engineering.

The process, in general, consists of concentrating the sulphuric acid pickle liquor by partial evaporation, reacting the concentrated waste pickle liquor with hydrogen chloride gas, and centrifuging the reacted mixture of sulphuric acid and ferrous chloride. The ferrous chloride is roasted to produce hydrogen chloride and iron oxide, and the hydrogen chloride gas is recovered by an absorption stripping system for recycle to the process.

The fundamental reaction of the process is $Fe\ SO_4 + 2\ HCl = Fe\ Cl_2 + H_2\ SO_4$. In this manner, the sulphate equivalent of the iron sulphate is recovered as reusable sulphuric acid, without use of a contact or chamber sulphuric acid plant.

The process provides an economical means of recovering waste pickle liquor from steel mills. Whereas, it is usually expected that pickle liquor recovery processes must operate at a loss and are justified only as waste disposal methods, this process, under favorable conditions, will show a profit.

"THE SCOPE OF THE FURNACE FUME CONTROL PROBLEM"

by H. L. RICHARDSON, District Manager, Research-Cottrell, Inc., Pittsburgh, Pa.

▲ THE steel industry is faced with the enormous problem of cleaning waste gases to reduce air pollution. This problem is complicated by the necessity of determining the final objective. Most of the present work is based on reducing the weight of suspensoids to a definite amount per measured amount of gas. This criterion for the measurement of stack discharge is ambiguous. New measurements to determine the light-obscuring power or visibility have been developed and calibrated by recent workers. Of particular interest is the work which has been done at Mellon Institute in Pittsburgh, which allows absolute values to be assigned to the measured capacity of a gas stream.

H. L. RICHARDSON

This new method expressed in "cohs" gives a reading in true values completely independent of the weight of material present. These measurements become particularly valuable in relation to fume discharge from ferrous pyrometallurgy. The individual particle size of the suspensoid from these processes is so small that the visual appearance of the stack discharge can be said to have little relation to the actual weight of the material present.

The collection of this fine material is peculiar to the field of electrical precipitation. This paper reports the magnitude of these problems in terms of gas quantity and amounts of material, principally for the open hearth and electric furnace with a brief coverage of the problem in parallel applications, such as the scarfing machine.

"VENTILATION OF STEEL MILL ELECTRIC EQUIPMENT"

By S. L. JAMESON, Construction Engineering Section, General Electric Co., Schenectady, N. Y.

S. L. JAMESON

▲ THE design of a ventilation system for a steel mill must take into account local atmospheric conditions, equipment to be ventilated, space available and operating personnel preferences. The system may be designed for either recirculating or non-circulating air flow or may be a combination of both.

The primary purpose of a ventilation system is to remove the heat losses from electrical equipment. This may involve removal of heat from equipment which could be operated "open" or may involve forced ventilation of machines to increase their capacity.

Air filters are a major factor in the design of the system. The type selected is dependent to a large degree on local conditions. Duplication of existing equipment is frequently desirable and improved designs and types must always be considered.

Filter maintenance is of utmost importance and the maintenance required may have a major effect on the type of filter installation.

In addition to filters, air coolers and other parts of the system where small amounts of dirt or carbon dust may accumulate must also be cleaned. In the case of water-to-air heat exchangers, this involves not only cleaning the inside of the tubes, but also the periodic inspection and cleaning of the outer finned surfaces.

TITANIUM - Its Progress and Applications

By T. E. PERRY
Metallurgical Dept.
and
R. J. GARMY
Engineering Dept.
Central Alloy District
Republic Steel Corp.
Massillon, Ohio

. . . . the know-how of the steelmaker is being used in the development of titanium alloys and in the production of this new metal . . . .

▲ TITANIUM and titanium alloys possess combinations of high strength, light weight and corrosion resistance unique in the family of metals. Present commercial alloys, for example, having densities little more than half that of steel are being supplied to tensile strength levels in excess of 150,000 psi. Developmental titanium alloys can be heat treated to considerably higher levels with relatively good remaining ductility. On a comparative basis, the corrosion resistance of pure titanium and most of its alloys puts it in a class with the hastelloys, stainless steel, and other of the more noble structural metals. In sea water it resists corrosion as well as platinum. Titanium has a very low coefficient of expansion, a low heat transfer rate, and an elastic modulus part way between aluminum and steel.

Titanium offers the designer a new and intensely interesting set of physical property relationships in a structural metal of potentially widespread availability. It suggests better ways of doing jobs where other available materials of construction have proven inadequate. It permits new designs that in the past have been impractical due to material limitations. It is an important and in some cases an almost indispensable addition to the family of engineering materials.

Like any new structural material possessing highly desirable characteristics, it is almost impossible to assimilate the vast reservoir of production, fabrication, and usage data common to some other more widely used materials before actual production and usage begin. There are, indeed, certain phases of production for example which are already obsolete due to the extremely rapid pace of development. Better methods for fabrication of all types become available at a steady and very healthy rate. New alloys and methods of alloying, better heat treatment and techniques for surface hardening, and countless other small parts of the overall technology of titanium are being developed and become available almost daily.

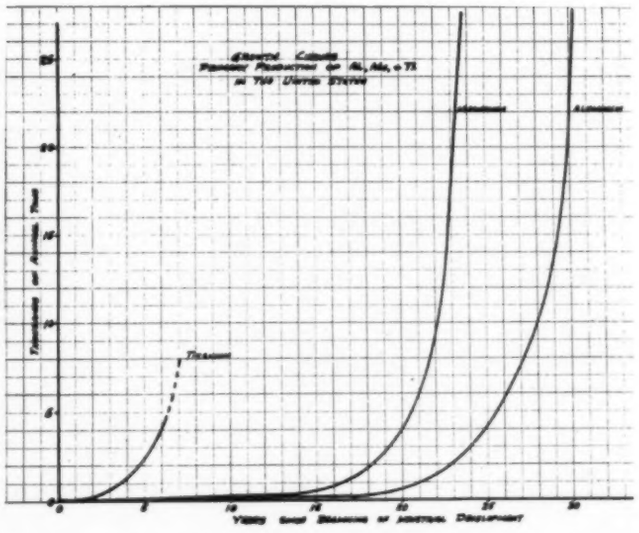


Figure 1 — Comparison of the growth curves in the United States for production of titanium, magnesium and aluminum shows that development of titanium has been much faster than the other two light metals.

The rapid expansion of a producing titanium industry in the United States has been deliberate and calculated. It may be interesting to note in Figure 1 that by way of comparison titanium production after approximately six years of industrial development has reached a level of between four and five thousand tons annually. To reach the same level of production required about twenty years for magnesium and twenty-five years for aluminum. This comparison becomes more significant when considering the vastly more complex technical problems associated with tonnage titanium production.

The rapid progress has been expensive. It has magnified many technical problems and promoted a strange alliance between people charged with theoretical research and others charged with production. It has meant many headaches for both the producer and the consumer, but this has been the price of rapid progress.

To the builders of aircraft and missiles for supersonic flight, who are facing heat and weight problems never before encountered and for which no alternate structural metals have proven wholly adequate, availability of titanium products has come at the time of the greatest need. To the Air Force, whose responsibility is air supremacy, availability of titanium product is an important factor in flying faster, further, and with more payload, now. The concept of global defense requires highly mobile, air dropped armies. Early availability of titanium products has indicated that air carried ordnance equipment can benefit greatly through titanium usage. In all these critical applications the need is now. The competitive edge can be gained now. It is not possible to wait for the normal development which might take twenty years.

Under-pinning this accelerated industrial growth and adding to the optimism of titanium usage in even the most critical of military applications, is the fact that basic titanium ore reserves of good quality are available over most of the world. The North American continent alone contains estimated ore reserves sufficient to maintain a producing industry for the forseeable future. The availability of domestic ore is an important economic as well as military advantage.

The common ores of titanium are rutile (TiO_2) and ilmenite ($FeTiO_3$). Of the two, rutile is the most desirable due to its high contained titanium ratio, but it is not nearly as plentiful as ilmenite. Most of the free world contains important ore deposits the majority of which are mixtures of ilmenite and rutile with ilmenite predominating. Australia is probably the outstanding exception, for here is located one of the most important known world deposits of predominantly rutile ore. The Maylayan peninsula, India, and Ceylon constitute another major potential source of high grade ore reserves.

Japanese beach sands are still another important source of good quality titanium ores, and a titanium producing industry is building rapidly in Japan. Florida and New York are the principal producing areas in the United States. American interests are developing extensive ore deposits in Southern Quebec on our northern border and in Mexico on the southern border. The Scandinavian countries possess important ore reserves, and large deposits are known to exist in Russia although no accurate estimates are available. It is perhaps, interesting to note that the Ilmen mountains of Russia were named after titanium's principal ore, ilmenite. Most other parts of the world have scatterings of less important ore reserves, but the principal deposits outlined will serve to illustrate the almost universal availability of this product.

It is possible to arrive at a vantage point in understanding many of the technical problems connected with "beyond-pilot-plant" production of titanium metal by briefly reviewing the fundamentals of extractive metallurgy as we know it today.

Just as iron ore feeds the blast furnace in steelmaking, TiO_2 concentrates feed the chemical reduction processes for titanium making. Concentrates of at least 90 per cent TiO_2 are required. Depending on the nature of the basic ore utilized, the concentrate is produced either by wet concentration or preliminary smelting. Using the high grade rutile deposits, wet concentration by centrifugal methods is satisfactory. In the case of ilmenite $FeTiO_3$, concentration may be accomplished by digestion with sulphuric acid, in which iron sulphate is a by-product or by a rather unique smelting operation developed specially for the upgrading of ilmenite ores. The latter method of concentration is being used in the development of the very important Southern Quebec deposit. In this operation large reverberatory type furnaces are charged with ilmenite ore and fired in a manner akin to open hearth steelmaking. At the completion of smelting, pig iron is tapped from under a TiO_2 rich slag, which with little further preparation is ready for the titanium recovery process.

The chemistry of the actual refining is simple enough in theory and can be expressed in equations one and two.

$$TiO_2 + 2\,Cl_2 + C \longrightarrow TiCl_4 + CO_2 \qquad (1)$$

$$TiCl_4 + 2M_s \longrightarrow 2M_sCl_2 + Ti \qquad (2)$$

In Step 1, TiO_2 is charged to a retort containing carbon and to which is fed chlorine gas. The TiO_2 and carbon are heated to about 800 C in the presence of chlorine. $TiCl_4$ vapor is collected and further refined to a pure colorless liquid.

Step 2 is more difficult and time consuming. Titanium is extremely reactive when hot and can absorb atmospheric gases and other impurities which render it brittle if not protected. In practice, large steel reactor chambers are charged with magnesium, which is maintained molten with external heat. An atmosphere of argon or helium is introduced within the entire closed reactor system and the $TiCl_4$ piped in. As the Mg reduces the $TiCl_4$ to form titanium sponge and $MgCl_2$, a large amount of heat is generated and external heat is removed. $MgCl_2$ is subsequently distilled off the spongy mass of titanium with heat and vacuum leaving titanium of 99.5 per cent purity.

This magnesium reduction method is commonly known as the Kroll process. It is long, expensive, and requires a high degree of control. It is also responsible for practically the entire production of basic titanium in the United States today.

The evolution of better and cheaper methods of refinement is inevitable, and progress is being made. A sodium reduction process, in which sodium is substituted for the Kroll process magnesium (it requires about one pound of high purity magnesium to produce one pound of Kroll process titanium) is said to be in "pilot-plant-operation." A process, wherein titanium is deposited electrolytically from a fused salt electrolyte such as potassium titanium fluoride, is also said to show a great deal of promise. Contrary to some reports, potentially important new processes such as those described are not likely to revolutionize the industry overnight. The tendency to look ahead to each new process as something comparable to Halls revolutionary process for aluminum is not valid. The problems are more complex with titanium, and while many theories look excellent as theories, the actual mechanics of producing high purity titanium by methods suitable

for large scale production are more difficult. It has taken about five years to bring the Kroll process to its present state of perfection, and there is still room for improvement.

Titanium sponge produced by any process must be melted and processed to usable product. Pure titanium melts at 3140 F. At its melting temperatures titanium is a universal solvent. No refractory is suitable for containing molten titanium without excessive metal contamination. Present melting furnaces are complex and highly sensitive pieces of equipment. The actual melting is accomplished in a water cooled copper hearth, either in a vacuum or under an argon or helium atmosphere. Usually, one or more direct current arcs supply bath heat.

The molten titanium freezes on contact with the cold copper so that as charge is added continuously, molten titanium actually is melted in a shell of solidified titanium. Only a small part of the total ingot is molten at any given time. The ingot is built up vertically in what could be visualized as a puddling operation. There are many modifications of this basic method of melting, and these, together with recent developments in the field, are appended for easy reference and review.

Titanium's excellent corrosion resistance to many of the most vicious corrosive environments is responsible for increasing usage in diversified non-military applications such as chemical plant equipment, food processing lines, orthopedic devices, anodizing racks, and others. The principal usage today, however, is in top priority high speed aircraft. A closer examination of this usage may help to define in a broader sense the parameters of usefulness of titanium in its present state of development.

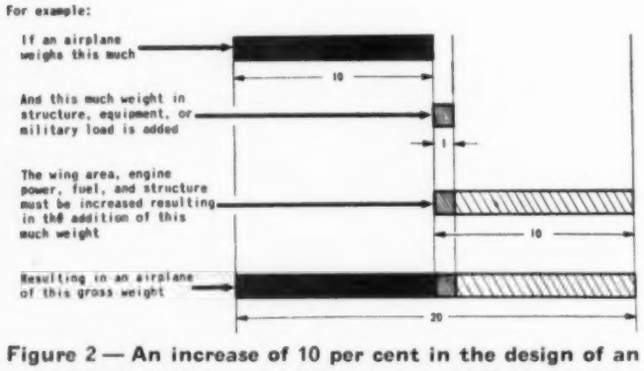

For example:
If an airplane weighs this much
10
And this much weight in structure, equipment, or military load is added
1
The wing area, engine power, fuel, and structure must be increased resulting in the addition of this much weight
10
Resulting in an airplane of this gross weight
20

Figure 2 — An increase of 10 per cent in the design of an aircraft results in a total increase of 100 per cent for the total weight.

There are a number of ways to express the importance of weight in aircraft. One of the most forceful is by describing it in terms of growth factor. In the design stage of an airplane a 10 per cent weight increase, as for example in anticipated payload or navigational equipment, can result in an approximate 100 per cent increase in total aircraft weight. To accommodate the original 10 per cent increase, wing area, engine power, and all load carrying members must be increased in a ratio which results in the 100 per cent total weight increase. This is obviously a 10:1 ratio, and airplane growth factor in this case is 10. Figure 2 shows the growth factor relationship graphically. This growth factor varies from one type of aircraft to another. It may be as low as 5 for slower propeller driven airplanes and as high as 15 or even 20 for higher speed jet fighters. It is also apparent that in designing a plane to carry a 20-ton tank, for example, any weight increase or reduction in tank weight will effect total aircraft weight in the same manner and by the same growth factor relationship described above for the airplane itself. Using the theoretical average growth factor of 10, it is readily apparent that a one lb weight reduction either in aircraft design weight or in anticipated payload weight

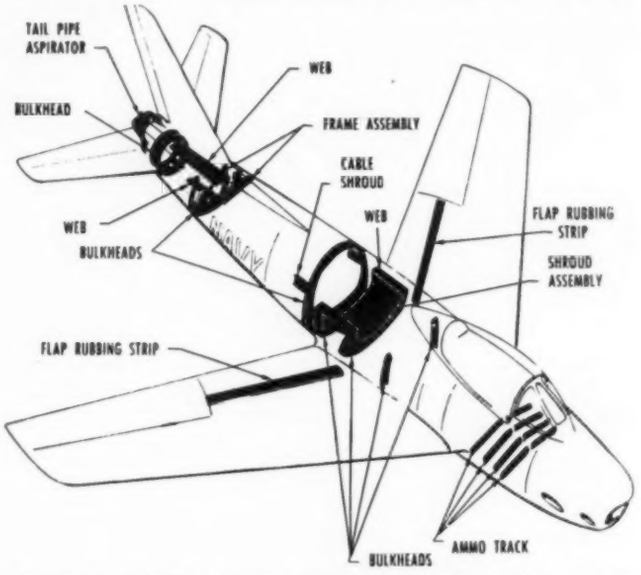


Figure 3 — Sketch shows typical applications of titanium in fighter planes.

can result in a 10 lb total weight savings, providing range, speed, and other performance characteristics are to remain constant. A rough figure used occasionally to estimate airplane cost is $40 per lb. Using this figure, a one lb weight increase or reduction, as the case may be, multiplied by a growth factor of 10 and a cost of $40, represents a cost increase or reduction of $400. Thus, there would appear to be sound economic as well as technical arguments for going to considerable pains in making weight reductions, however small in design stage aircraft as well as in the payloads they are expected to carry.

The Air Force as well as the Ordnance Corps realized several years ago that titanium with its high strength to weight ratio and excellent corrosion resistance could be an important factor in meeting the needs described. It was with an almost blind faith in what might be accomplished with this new structural metal that industrial development and production were accelerated to the maximum. The first airplanes to use titanium were not designed specifically for it. Titanium was at first substituted section by section usually for stainless or alloy steel in existing aircraft at a direct weight saving of about 40 per cent per part. Although growth factor advantages were not realized in these early applications, significant weight savings did result, but more important, fabrication experience and usage data were obtained that enabled designers to plan subsequent aircraft into which titanium could be designed such that true growth factor relationships could be realized. Figure 3 shows typical direct substitution usage of titanium in the North American FJ-2 Fury. From such applications came the design data and fabrication knowhow for

increased utilization of titanium in today's and tomorrow's top performance aircraft under conditions where maximum weight savings are possible. Aircraft usage of titanium varies, but important areas of application are in fuselage areas around the jet engine where temperatures may be as high as 400 F due to engine heat in fire walls, and in hot gas ducting. In more advanced aircraft, air friction due to supersonic flight may result in skin temperatures too hot for other "light metals," and titanium can be used with appreciable weight saving over the alternate choice, stainless steel.

Jet engines are as sensitive to weight in relation to growth factor as the air frames themselves since together the engine and the aircraft structure operate as a unit. The greater part of a jet engine, the compressor area, including up to 15 or more compressor wheels together with blades and structure, operates in a temperature range where the strength to weight ratio of titanium is superior to most alternate structural materials. Excellent opportunities for appreciable weight savings in the compressor section are apparent from the sketch in Figure 4. The excellent corrosion resistance of titanium is an important consideration in applications such as blading where corrosion fatigue can be a serious problem. Large scale utilization in critical engine parts has been somewhat slower, however, than in air frames. In dynamically loaded intermediate temperature applications such as these, a good deal of caution and operating data is required. Various alloy types are presently being evaluated in actual engine tests to accumulate as rapidly as possible the empirical data required for production application. Compressor wheels, weighing over 100 lb in some cases, compressor blades, spacer rings, shrouds, and many other compressor section components have been produced in quantities for large scale engine evaluation. Test results indicate that in the near future, titanium will make major contributions in high thrust to weight ratio production engines.

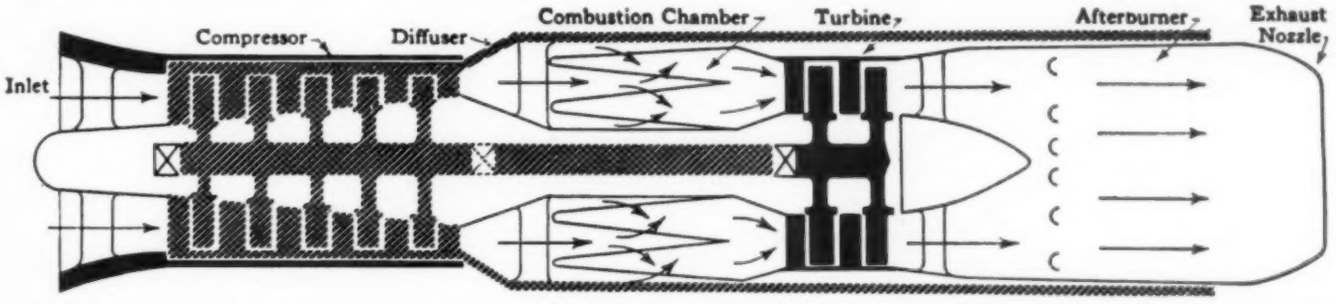


Figure 4 — Sketch shows typical points for use of titanium in jet engines. Cross hatch areas are parts where titanium now find a logical use. Solid areas show parts which will use titanium alloys still being developed.

Titanium has received the close attention of Army Ordnance relative to its use in air-borne and light weight combat equipment of many types. Actual firing tests show that weight-for-weight titanium armor can be 25 per cent more effective than steel armor, or conversely, for the same relative protection, titanium armor can be 25 per cent lighter. Outriggers for gun carriages, mobile gun mounts, and even recoilless rifle barrels have been produced experimentally from titanium in an effort to find out where and how much weight saving can be made in equipment that may be air carried and dropped thousands of miles from a home base.

Titanium's exceptional corrosion resistance together with its high strength to weight ratio is responsible for increasing usage in non-military applications as well.

Titanium completely resists attack by sea water, salt brines, and wet chlorine gas. Its excellent resistance to such vicious pitting environments as hot and boiling cupric and ferric chloride solutions and in sodium and calcium hypochlorites is especially interesting. Titanium resists attack by nitric acid in all concentrations and may be used in dilute solutions of sulphuric or hydrochloric acids at room temperature or in stronger solution at higher temperatures providing an inhibitor is added. Many heretofore perplexing corrosion problems are being solved with titanium, and as the total knowledge of titanium's corrosion resisting properties becomes better known, a substantial area of usage is becoming better defined in chemical plant equipment, food processing equipment, pharmaceutical equipment, orthopedic devices such as bone plates, hip joints, and nails, and in various marine applications.

In order to accomplish the specialized jobs required of diverse applications, a large part of the total research effort on titanium has been devoted to alloy development. A representative cross-section of some commercially available titanium grades is tabulated in Table I. The two grades containing a Suffix X in their designation should be considered as developmental in nature since end use evaluation is not yet complete. The trends in alloy development which they represent are important, however, and seem worthy of brief review.

RS-110-BX was designed to fill a specific need for a moderately high strength, ductile sheet product which would be fusion weldable. RS-140X is typical of what may be a new family of titanium alloys which is heat treatable to very high tensile strengths. At present, this material is recommended for service in the annealed condition only, but heat treat data as shown in Table II suggests fertile fields for further investigation of heat treatable titanium alloys. Such an investigation is presently in progress on an industry-wide basis.

Figure 5 presents an interesting picture of how titanium compares with other commonly used structural metals on a strength to weight ratio basis at several temperatures. It can be noted that aluminum alloy 75ST shows a better ratio up to about 200 F than stainless steel Type 302 and titanium sheet alloys. It is not as high as some titanium alloys produced in bar forms. A 7 per cent Mn titanium alloy sheet shows a significant advantage over both aluminum and stainless steel above about 200 F. Commercially pure titanium

TABLE I

Some typical, commercially available titanium types showing physical constants and wide range of properties obtainable.

Properties of Republic — Titanium and Titanium Alloys

	RS-55	RS-70 and RS-70-A*	RS-110	RS-110-A	RS-110-BX	RS-120	RS-130	RS-140-X	Type 302 stainless steel
Nominal chemistry, per cent	C 0.20 max Ti bal	C 0.20 max Ti bal	C 0.20 max Cr 3.5 Fe 1.5 Ti bal	C 0.20 max Mn 7.0 Ti bal	C 0.20 max Mn 3.0 Al 1.5 Ti bal	C 0.20 max Mn 7.0 Ti bal	C 0.20 max Mn 4.0 Al 4.0 Ti bal	C 0.20 max Cr 2.75 Al 5.0 Fe 1.25 Ti bal	C 0.08-0.20 Mn 2.00 max Si 1.00 max Cr 17.00-19.00 Ni 8.00-10.00
Mill forms	Sheet Plate Billet Bar Wire	Sheet Plate Billet Bar Wire	Billet Bar Wire	Sheet Plate	Sheet Plate Billet Bar Wire	Billet Bar Wire	Billet Bar Wire	Billet Bar Wire	All standard mill forms
Physical properties — Density, lb per cu in.	0.163	0.163	0.168	0.170	0.165	0.170	0.165	0.163	0.29
Modulus of elasticity, x 10^6 psi	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	28.0
Principal microstructure	Alpha HCP	Alpha HCP	Alpha HCP + Beta BCC	Alpha HCP + Beta BCC	Alpha HCP + Beta BCC	Alpha HCP + Beta BCC	Alpha HCP + Beta BCC	Alpha HCP + Beta BCC	Austenitic FCC
Approx specific heat, Btu/°F/lb	0.13								0.12
Approx thermal conductivity, Btu/ft²/hr/°F/in.	110								113
Approx linear coefficient of thermal expansion x 10^6/°F	5.0					5.5			10.9
Magnetic property	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic	Non-magnetic
Approx electrical resistivity, microhms/cm³ @ 70 F	61.0								72.0
Mechanical properties — Approx annealed hardness	Rb 85-90	Rb 94-100	Rc 26-32	Rc 28-34	Rc 25-30	Rc 29-35	Rc 30-36	Rc 34-40	Rb 75-90
Tensile strength, minimum nominal	65,000 73,000	80,000 89,000	120,000 125,000	120,000 126,000	120,000 aim 123,000	130,000 145,000	140,000 150,000	150,000 164,000	80,000 90,000
Yield strength, 2 per cent offset, minimum nominal	55,000 62,000	70,000 82,000	110,000 116,000	110,000 118,000	110,000 aim 117,000	120,000 134,000	130,000 142,000	140,000 158,000	35,000 45,000
Per cent elongation in 2 in. or 4d, minimum nominal	20 27	18 22	12 18	10 18	12 18	12 20	10 15	10 15	10 55
Nominal impact, Charpy, 70 F	25-40	20-35	15-20			10-20		10-15	70-110
Nominal bend radius, 90 deg V block — 0.070 in. gage and under 0.070 in.—0.250 in.	1-2 1.5-2.5	1.5-2.5 2-3		3-4 3.5-4.5	2-3 3-4				
Annealing	15 min @ 1250 F, air cool	15 min @ 1250 F, air cool	1 hr @ 1250 F, slow cool	15 min @ 1250 F, slow cool	20 min @ 1250 F, slow cool	1 hr @ 1250 F, slow cool	1 hr @ 1350 F, slow cool	1 hr @ 1450 F, slow cool	Cool rapidly from 1850-2050 F
Stress relieving	20 min @ 1000 F, air cool	20 min @ 1000 F, air cool		20 min @ 1000 F, air cool					Same as annealing
Heat treatment	None	None	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended	Hold 2 hr @ 1450 F, water quench Temper 700-1100 F, 4-24 hr	Non-hardening
Forging, °F	1200-1600	1200-1600	1300-1700		1300-1700	1300-1700	1350-1750	1400-1750	1700-2200
Weldability	Good	Good	Flash welding only	Flash welding only	Good (Normalize fusion welds)	Flash welding only	Flash welding only	Flash welding only	Very good

*RS-70-A differs from RS-70 only in that 1.25 per cent max Mn has been added.

TABLE II

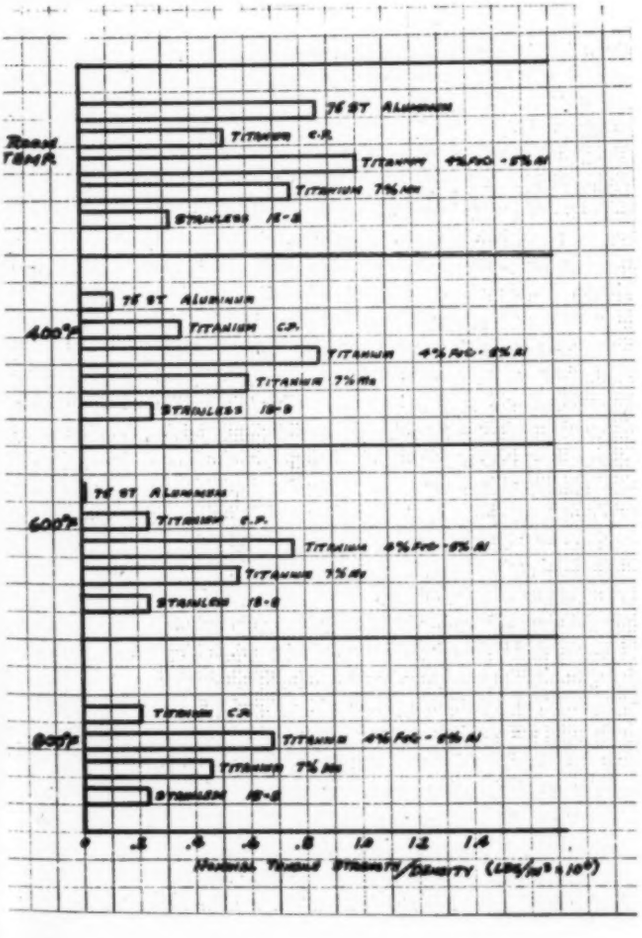
Effect of heat treatment on 4 per cent ferrochrome, 5 per cent aluminum alloy.
Heat treatable titanium alloys represent a comparatively new trend in alloying of which this grade is typical.

Treatment	Yield strength, psi	Tensile strength, psi	Per cent reduction of area	Per cent elongation in 1½ in.
1450 F, 2 hr, water quench, draw 900 F, 4 hr, air cool	198,000	204,000	24.6	8.6
1450 F, 2 hr, water quench, draw 900 F, 24 hr, air cool	193,000	200,000	17.1	8.0
1450 F, 2 hr, water quench, draw 1000 F, 4 hr, air cool	192,000	198,000	24.6	8.6
1450 F, 2 hr, water quench, draw 1000 F, 24 hr, air cool	187,000	191,000	11.2	5.3
1450 F, 2 hr, water quench, draw 1100 F, 4 hr, air cool	175,000	181,000	24.6	8.0
1450 F, 2 hr, water quench, draw 1100 F, 24 hr, air cool	173,000	178,000	11.2	7.3
1450 F, 2 hr, water quench, draw 1200 F, 4 hr, air cool	164,000	168,000	38.5	12.0
1450 F, 2 hr, water quench, draw 1200 F, 24 hr, air cool	162,000	166,000	38.5	12.0
1450 F, 2 hr, water quench, draw 1300 F, 4 hr, air cool	160,000	163,000	44.5	14.0
1450 F, 2 hr, water quench, draw 1300 F, 24 hr, air cool	158,000	162,000	42.8	14.0

shows an advantage over aluminum at temperatures above about 300 F. The 5 per cent Al 4 per cent FeCr titanium alloy is attractive in all comparisons from room temperature to 1000 F.

Such comparisons help in visualizing certain areas of usefulness but are dangerous in other ways. Properties such as creep, fatigue, corrosion resistance, impact strength and others are very often factors limiting design and should be carefully weighed in selecting applications. Consideration of such properties have generally limited application of titanium and titanium alloys to applications where service temperature does not exceed about 700 F. New alloys should extend this temperature range to 900 or even 1000 F in the not too distant future.

Figure 5 — Chart shows effect of temperature on properties of several alloys.



By way of summary one can observe that in the approximately six years of titanium's commercial development, a good deal of progress has been made. Unusually complex problems relating to basic ore refinement have been solved to the extent of workable commercial processes. Present processes show signs of evolving into better and cheaper methods as process knowledge grows. Parameters of utility of wrought titanium are becoming better defined. Aircraft and airborne military equipment are and will continue to use increasing tonnages of titanium as it becomes available. The weight saving interpreted in terms of airplane growth factor appear technically and economically sound wherever titanium can be used to advantage. Usage data in non-military applications for titanium is increasing and some titanium product has been set aside to encourage developments of this type.

New alloy types and continuing emphasis on alloy development are expanding potential usage areas. Many problems still remain to be solved before the infant titanium industry reaches the size or relative importance of the sister industries which have developed around aluminum or stainless steel. Titanium's unique combination of high strength, light weight, and corrosion resistance coupled with widely available domestic ore reserves seem to insure the ultimate solution of these problems and should assure titanium an important position in the family of metals.

As an appendix to this report a reference guide to melting techniques and procedures for titanium is presented.

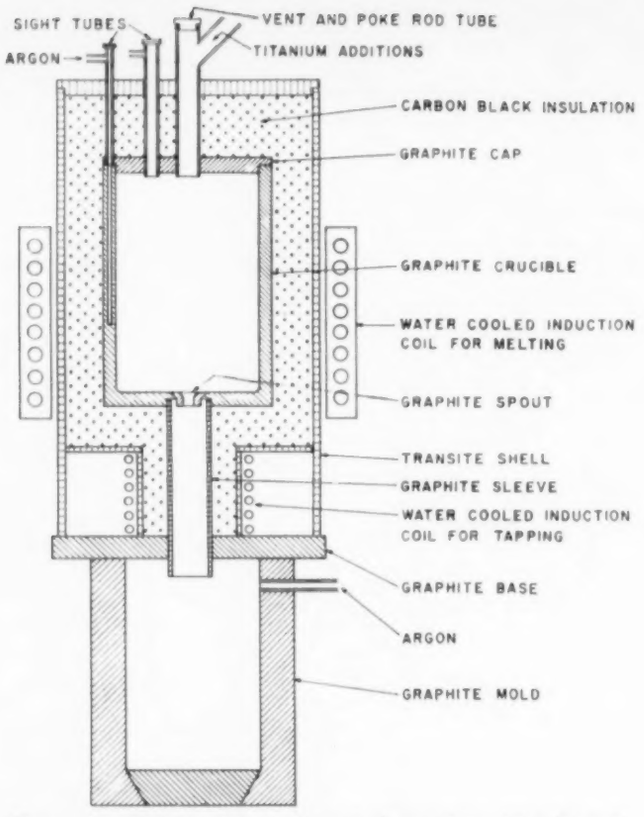


Figure 6 — Schematic sketch of elementary titanium induction furnace.

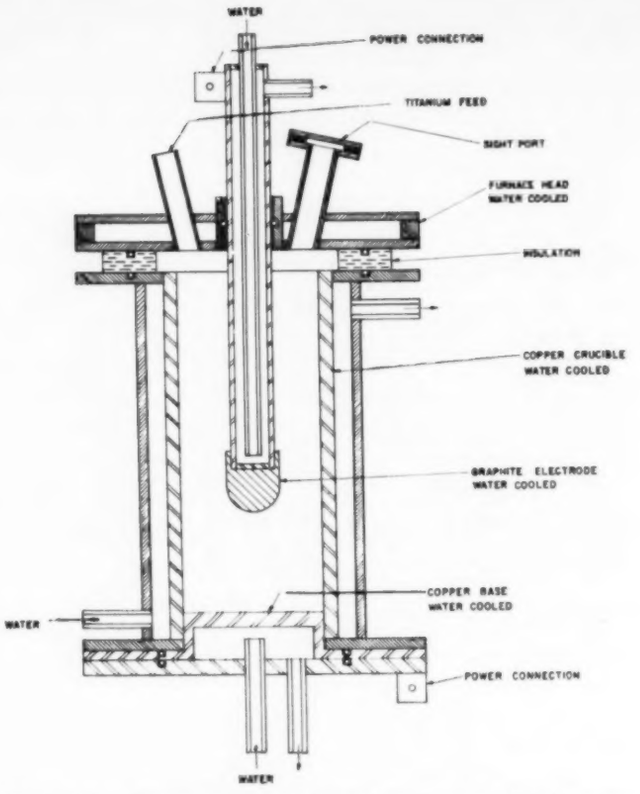


Figure 7 — Schematic sketch of elementary titanium arc furnace.

APPENDIX

Review of four basic melting processes for Titanium

Figure 6 illustrates an elementary titanium induction furnace. The charge is contained within the crucible and bottom tapped into the mold below. The crucible is graphite and represents the inductive load, the heat being transmitted to the charge by conduction. Carbon black and a non-magnetic containing shell provide effective insulation against excessive heat losses and oxidation of the graphite. Provisions are included for temperature checks and to make titanium additions during melt down. An inductively heated sleeve facilitates tapping. Heats are generally made under an argon atmosphere although a vacuum could be employed through suitable design changes. Typical power consumption is 0.6 kwhr per lb of titanium.

Figure 7 illustrates an elementary titanium arc furnace of the non-consumable electrode type. Bath heat is supplied by a direct current arc. The electrode itself is usually constructed of graphite and operated electrically negative. The molten titanium freezes on contact with the cold copper so that as charge is added continuously, molten titanium actually is melted in the shell of titanium solidified against the copper crucible wall. Only a part of the total ingot is molten at any given time. As the ingot is built up vertically, the electrode is raised—normally by automatic means. Furnace atmosphere could range all the way from argon or helium to a vacuum. Many modifications of this basic form of melting have been built including designs with a plurality of electrodes and of sufficient power and capacity to produce a 4000-lb ingot. Typical power consumption for the larger furnaces is 2 kwhr per lb of titanium.

Figure 8 illustrates a typical elementary consumable electrode furnace. The name is derived from the fact that the electrode is purposely consumed in the melting process and thus provides the feed for the ingot. The consumable electrode also supplies bath heat using a direct current arc with the electrode maintained electrically negative. Again, with this type of melting, the molten titanium freezes on contact with the cold copper so that as the ingot builds up molten titanium is contained within a shell of solidified titanium. Also only a part of the total ingot is molten at any given time. Like the previously described arc furnaces, the melting atmosphere could range all the way from argon or helium on the pressure side to a vacuum.

There are no design limitations on this type of furnace as to number of electrodes or size.

The electrode is fabricated from titanium sponge or scrap or both. One fabrication method employed consists of pressing the sponge into a desirable shape in increments which can be subsequently attached to one another until a desirable electrode length is obtained. This operation can be made a part of the furnace or handled separate and external from the melting furnace.

"Consumable Double Melt" is a term often used and simply means a remelting of a series of first melted ingots. The furnace is essentially the same as that already described although larger to accommodate the increased ingot size. Typical power consumption in a consumable furnace is 1.4 kwhr per lb for each melting.

Figure 9 represents an elementary titanium skull furnace. The design shown incorporates a water cooled shell in which a solidified titanium shell or skull is deliberately maintained.

The molten titanium is maintained within this solidified skull. Bath heat may be supplied by a direct current arc from a consumable, or non-consumable electrode maintained electrically negatively. The tilting shell permits tapping the heat into a suitable mold.

Furnace atmosphere once again can range from argon or helium to a vacuum. There appears to be no design limitations as to size or number of electrodes.

DISCUSSION

PRESENTED BY

GEORGE W. BELCHER, Technical Sales Engineer, Titanium Metals Corp. of America, New York, N. Y.

GAIL P. McCLEARY, Engineer, Thompson Products, Inc., Cleveland, Ohio.

T. E. PERRY, Metallurgial Dept., Central Alloy District, Republic Steel Corp., Massillon, Ohio.

S. O. EVANS, Manager—Tubing Operations, Tubular Products Div., Babcock and Wilcox Co., Beaver Falls, Pa.

R. J. GARMY, Engineering Dept., Central Alloy District, Republic Steel Corp., Massillon, Ohio.

WILLIAM HOLT, Specialist, Industrial Heating Sales, Canadian General Electric Co., Ltd., Toronto, Canada.

ROGER GILER, Engineer, Westinghouse Electric Corp., Meadville, Pa.

George W. Belcher: I would like to explain a little bit further, one point Mr. Perry made and that was on the extreme urgency in the development of titanium.

Right now, for example, we can go back to sponge production and stay away from mill products. On sponge production the government is asking 35,000 tons a year by the end of 1957. At the present moment on their program there is only 15,000 tons capacity. Now that is composed of 3600 tons by our company, Titanium Metals, 3600 tons from duPont, 6000 tons from Cramet (they are just starting; they should be in capacity production in '55). There is one other one, the Dow Chemical Co. of Midland, Mich., who will be producing approximately 1800 tons by 1956. So you can see production is at the present moment falling short.

I understand that the Electro-Metallurgical Corp. is starting up and they will attain an estimated tonnage of around 8000 tons. Their contract is in the termination stage now, and it will take some time to get to the complete capacity.

Other than the United States there are only two major producers of sponge. One is Japan, which is only producing at this time around 50 tons a month and the other Imperial Chemical Industries in Wilton, England who are constructing a 3500-ton annual capacity plant.

Gail P. McCleary: I would like to know the stage of development in the production of castings from titanium.

T. E. Perry: You can always provoke an interesting discussion when you talk about titanium castings. There are obvious problems, particularly in the construction of a suitable melting furnace.

The first requisite for casting is that the metal must be maintained molten in a sizable pool without con-

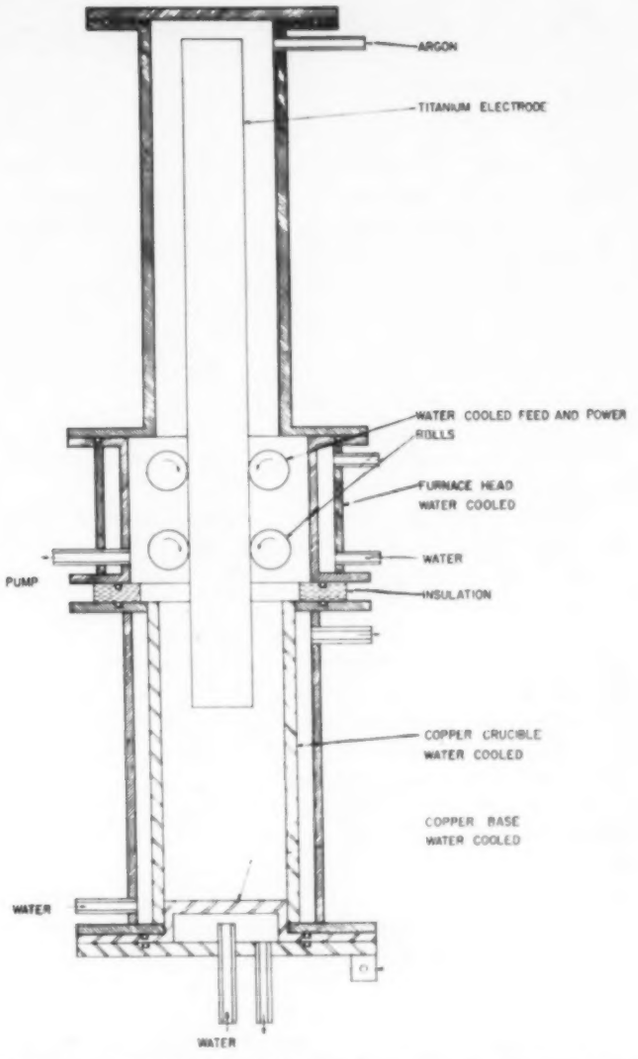
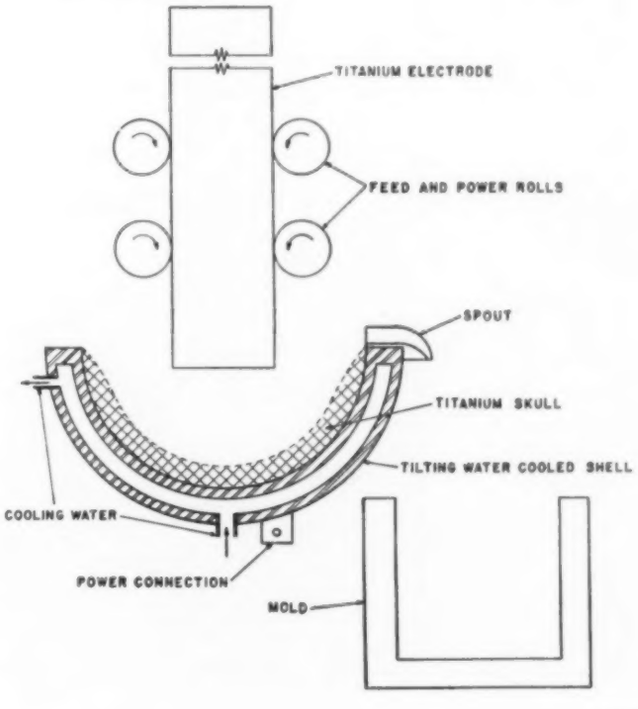


Figure 8 — Schematic sketch of elementary titanium consumable electrode furnace.

Figure 9 — Schematic sketch of elementary titanium skull furnace.



tamination and with accurate bath temperature control just prior to pouring. Melting furnaces capable of doing this job are being developed. The skull type furnace that we reviewed earlier is the basic approach to furnace design.

The second requisite for casting is that once the metal is poured and in the mold it must not become contaminated. I have already told you that no known refractory will hold molten titanium without contamination. Designing the mold to provide adequate chill effect at the surface can eliminate all or practically all of the mold contamination. This was actually found to be the case in our early ingot castings from an induction type furnace into graphite and other type ingot mold.

If mold contamination does occur, it should be limited to the extreme outer skin which can be removed with excellent accuracy by chemical means.

The answers to the two basic problems, furnace design and molding technique, are broadly defined. It remains to fill in the detail work to make commercial titanium castings a reality.

S. O. Evans: I would be interested in some of the non-military applications of titanium.

T. E. Perry: That is a question that is being asked more and more today. The value of titanium to the military, particularly in the long pull, would be greatly enhanced by a strong non-military usage.

The non-military applications that have been developed to date are based largely on the metal's corrosion resistance. Some take advantage of both the corrosion resistance and the light weight. As an example, not so long ago we supplied titanium samples for a process involving the preparation of chlorine dioxide. Certain parts of this equipment posed critical corrosion problems. The particular application required replacement of the best alternate material every two weeks. Titanium has been used in the application now for two years and shows no signs whatsoever of corrosion.

Marine applications of many types offer excellent applications for titanium.

Again, the ability to build a non-military market is dependent to a large extent on the ability of the industry to reduce the price of titanium to the point where it can compete economically with more of the common metals used in industry. The final price level is difficult to predict. At $10 to $20 a pound today titanium is used economically in some non-military applications. As the price comes down, usage in non-military applications will increase rapidly.

A very interesting application taking advantage of both light weight and corrosion resistance is in high speed centrifugal separators handling corrosive media. Centrifugal force actually limits the maximum diameter of these units to a surprisingly modest figure. The same units can utilize titanium to increase either size or rpm with greatly increased efficiency.

Member: I would like to ask comments on the relative efficiency of d-c versus a-c arcs in the furnaces you have been discussing.

R. J. Garmy: As in the development of all melting furnaces, the design engineer has tried with both d-c and a-c arcs. In this particular case, d-c arcs have always been used in graphite arc, and so-called consumable furnaces for various reasons. One was to try to operate the bath at a much higher temperature than the electrode. This was very true in the graphite arc furnaces. There are other furnace conditions that dictate the use of d-c arcs and the subject becomes quite complex. I believe all people are now using d-c arcs. It is not a matter of economy of the type of arcs, it is a matter of the need or the operating principle of the furnace itself.

William Holt: I would like to check on one thing; the analysis of the experimental alloyed titanium. Was the chrome 4 per cent and aluminum 5 per cent, and when were the additions made? Would they be charged into the consumable electrode furnace with the titanium sponge, or after the meltdown?

T. E. Perry: The analysis was 4 per cent ferrochrome—5 per cent aluminum. The ratio of chromium to iron is approximately 2:1. The alloy addition is made as a master alloy. In either consumable or non-consumable type melting the addition is continuous during melting.

Roger Giler: I have heard that a new process has been developed for the manufacture of titanium: an electrolytic type process. I did not hear you mention it. From what has been said about this process, it appears that it could be more economical and also yield titanium with a low hydrogen content. May we have your comments?

T. E. Perry: There are several processes that can be carried out on paper with equations to arrive at high purity titanium. Unfortunately, all these processes are not suited to economical production. Some of the things we look for in a commercial process are these: the titanium first of all has to be at least 99½ per cent pure. The physical form has to be such that the constituents used in producing it, such as electrolytes, can be efficiently removed. Impurities, for instance, such as magnesium chloride in Kroll process sponge can limit the meltability of the titanium with some furnace designs.

Various electrolytic processes have been under development for three or four years. We have yet to see a satisfactory electrolytic product. We hope very fervently it will come. If such a process works there are basic economies that should be realized.

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CONTINUOUS BATCH TYPE ANNEALING FURNACE

By RALPH H. GELDER
Works Metallurgist
and
WALTER E. HAND
Supervising Metallurgist
Armco Steel Corp.
Ashland, Ky.

. . . . this type of annealing furnace has given greater production with lower fuel consumption . . . .

▲ IN the manufacture of certain grades of iron and steel products, it is customary to provide an anneal involving low heating and cooling rates to impart certain desirable properties, generally softness and ductility, to the product. Since this process usually is performed in a protective atmosphere enclosed by a suitable cast or sheet metal bell, or box, it has been given the term "box annealing." Steel and iron sheets and plates, particularly, are customarily submitted to box annealing where extraordinary ductility is required.

During recent years, most producers of flat rolled steel have adopted the portable bell type of box annealing furnace as successor to the older style, single door, stationary fired furnace. However, Armco Steel Corp., in completing equipment for processing the product of the original continuous sheet rolling mill at Ashland, Ky., in the middle '20s, built two tunnel furnaces for box annealing. These furnaces, adapted from the ceramics industry, each held twelve boxes, which were charged at such intervals and given such firing as to produce the desired temperatures in the material being annealed. Furnace construction, layout and operation were such that boxes moved intermittently, but progressively, through the furnace, an annealed box being discharged from one end whenever a cold box was charged into the other end.

Satisfaction experienced with these furnaces led to the construction of an additional two furnaces of the same general characteristics when need arose to expand facilities a few years later. These continue in use to this time.

About three years ago, conditions arose which demanded a further increase in box annealing capacity. The continued general satisfaction with the continuous type of furnace resulted in the adoption of an improved model of this type of furnace to meet the needs of this expansion.

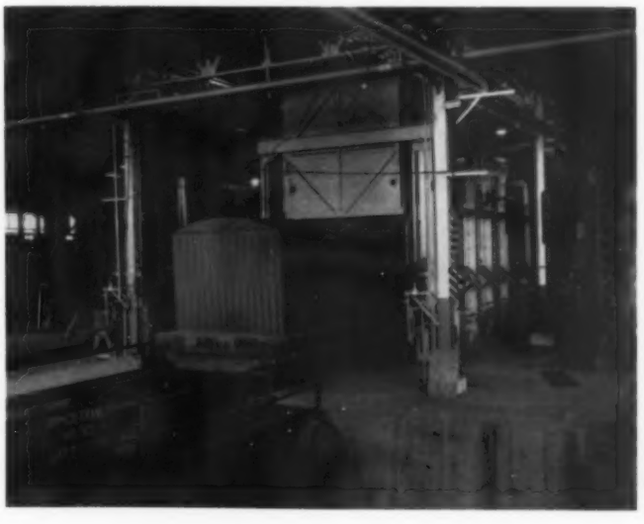
The first two years' operation of this furnace have thoroughly justified the decision to build a furnace of this design and have revealed advantages in excess of expectations. Production of the furnace has been at a rate of approximately one ton per hour per box under fire, as compared with ¾ ton per hour of similar material in comparable loading in portable bell furnaces. Fuel consumption rates have shown even greater advantage, the new furnace requiring 1,250,000 Btu per ton, while the bell type furnaces have consumed 2,500,000 Btu per ton. Temperatures have been controlled with greater precision than was possible with the bell type furnaces, and differential between hottest and coldest spots in the charges at the completion of the anneal is significantly less.

Two factors in design and construction of the furnace appear to be principally responsible for the attainment of these advantages. One is the placement and arrangement of burners so that heat input is concentrated at the bottoms of the charges. The other is the provision of complete equipment for precise control of temperatures at the significant points in the charges. These features will be explained in the remainder of this paper.

FURNACE OPERATING PROCEDURES

In general layout, this furnace resembles a tunnel, containing space for twelve loaded boxes on car bottoms. At each end of the furnace there is a pit, in which

Figure 1 — Exit end of furnace shows discharged box on track between furnace and transfer lorry.



a transfer car or lorry operates at right angles to the direction of travel of the boxes through the furnace. Cars are propelled onto and off from the transfer lorry and through the furnace and parallel cooling lines by pusher mechanisms built into the transfer lorries. Pits or stalls, into which the cars may be pushed by the transfer lorry for loading and unloading are located along the side of its operating pit opposite the entrance to the furnace. These loading pits are served by an overhead crane.

Routine operating procedure is as follows:

A car bottom is loaded with the charge to be annealed and covered in one of the several loading pits. The transfer lorry picks up the car and moves it to a point in line with the tracks under the furnace, where it is pushed into the space on the tracks between the transfer pit and the furnace entrance. At that point, the seal between cover and base is filled with sand, and the interior of the box is flushed with the gas used for protective atmosphere. At the proper time the box, thus prepared, is pushed into the position, in the furnace, immediately inside the entrance door. Since the furnace, already in operation, is filled with its 12 boxes, each box is moved forward to the position adjacent to the one previously occupied by the box, and the box in the last position is pushed out of the furnace exit door. At this point, the discharged box is picked up by the exit end transfer lorry and moved to the cooling track. Figure 1 shows this operation at the exit end of the furnace.

Cooling, under natural influences, takes place while the loaded boxes recycle down tracks parallel to the furnace to the entrance end transfer lorry, which picks each cooled car up and spots it in a loading pit for repetition of the cycle described.

As previously mentioned, other furnaces are located parallel to the one described, and are served by the same transfer lorries and cooling tracks. Because of difference in the width of the car bottoms between the new and old furnaces, loading stalls cannot be used interchangeably.

Charging frequencies, as well as furnace and work temperatures are selected for the type of anneal to be performed. Method by which control of temperatures is accomplished is considered to be unique and will be described in detail later.

Figure 2 — Charge of plates, before covering, shows details of annealing bottom and placing of thermocouples.

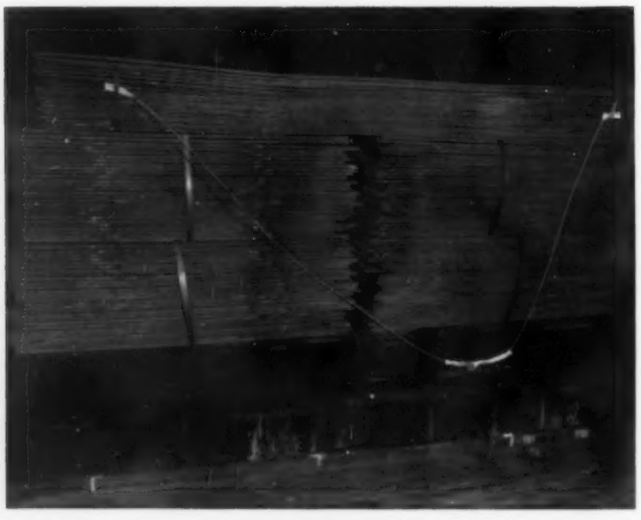


Figure 3 — View of side of furnace illustrates manner of mounting burners.

DESCRIPTION AND SPECIFICATIONS

This furnace was built to Armco specifications. The location chosen was such that the loading, charging and cooling facilities provided for the older furnaces would also serve the new installation. Thus, this furnace was placed adjacent to the older furnaces, with its car bottom tracks leading to the transfer lorry pits on either end. Figure 1 shows the general arrangement of facilities at the exit end of the furnace, with the discharged box on the track leading from the furnace to the transfer lorry. Exit doors of two of the older furnaces may be seen to either side, and a box on one of the cooling tracks is visible in the left background. Similar arrangements exist at the entrance end of the furnace.

Each annealing box is built upon a car bottom, 15 ft 11½ in. long and 8 ft 6 in. wide. Top of the car bottom, without refractories, is 2 ft 2¾ in. above the rails. Wheels are 18 in. in diameter, double flanged, and are mounted on roller bearing axles on 3 ft 5½-in. centers. Axles are symmetrically mounted under the car bottom on 7 ft 10½-in. centers. A refractory stool, 6 ft 9 in. wide, 12 ft 9 in. long and 1 ft 2½ in. high, centered on the car bottom plate serves to carry the load and to provide insulation to prevent heat loss through the bottom. Further insulation and proper spacing of the load with respect to the source of heat is provided by the use of 12 × 12 × 9-in. piling blocks on the top of the refractory stool. These are shown in place in Figure 2, and may be constructed of welded plate or cast iron or steel as facilities permit. A sand seal, receiving the bottom edges of the cover, is formed by a circumferential fence of cast iron shapes.

Exterior covers are constructed of plates of steel of an analysis to provide the requisite heat and corrosion resistance for the conditions imposed by the particular annealing cycle and temperature to be used. One of the standard stainless grades usually suffices. Sides and ends are made of corrugated plates and the tops are formed from flat plates. Interior cover dimensions are 7 ft 4 in. wide, 13 ft 7 in. long and 6 ft 11½ in. high at center.

Dimensions recited above were designed to enclose loads of 6 ft 3 in. maximum width, 12 ft 8 in. maximum length and 4 ft 0 in. maximum height, provided however, that the maximum weight be 50 tons. This weight limit was imposed by decision not to reinforce, at the time, the charging and transferring equipment which was originally designed and installed to serve the smaller older furnaces.

The furnace proper is 192 ft 0 in. long, accommodating twelve of the boxes described above. The width, 12 ft 0 in., allows ample combustion space between each side of the box cover and its corresponding furnace wall. Interior height, 11 ft 5¼ in. above the top of the rails, allows 1 ft 10½ in. between the average box top and the crown. Doors on each end, 9 ft 0 in. wide, are opened electrically by vertical lift to clear the tops of the box covers. The bottom of the combustion chamber is formed by a ledge extending in from the wall, the top of which is 3 ft 7 in. above the tops of the rails. This is slightly higher than the tops of the sand seal castings, which are thus protected from the effect of direct flame impingement. Burners are mounted in the walls at an angle of 45 degrees downward from horizontal, so that the flame is directed against this ledge, deflecting upward along the box cover sides. Mounting of the burners, as viewed from the exterior of the furnace is shown in Figure 3. Fuel is 1000 Btu per cu ft natural gas and combustion air is fed from low pressure blowers. Customary safety interlocking is employed.

Burners are distributed as to number and size along the furnace walls according to the probable distribution of heat demand. Each box position is designated a "zone" for purposes of firing and temperature control. The two sides of the furnace at each zone are fired and controlled independently, although always at the same temperature. Since those zones toward the entrance end of the furnace serve to provide the major part of the heat required to bring the boxes charged to annealing temperature, they are fitted with more and larger burners than the following zones. Each side of each of the first four zones is equipped with six burners, each with air orifice of 1.07-in. diameter and gas orifice of 0.41-in. diameter. Each side of the remaining eight zones has three burners with 0.816-in. diameter air orifice and 0.306-in. diameter gas orifice. Air is furnished by low pressure blowers to the No. 3 burners at 5 in. water maximum pressure and to the No. 2 burners at 7 in. maximum. Gas is fed through reducers from higher pressures to the No. 3 burners at 4 in. maximum, and to the No. 2 burners at 6 in. maximum. Burners are distributed symmetrically with respect to the centers of the box positions.

Protective atmospheres of DX gas, natural gas, or a mixture of the two, as required, are maintained within the boxes from a main feeder line running beneath the cars, with each car carrying its section with an outlet leading to the interior of the box. As each car is charged, its gas feeder line is coupled to the one of the car ahead through pipe unions and joints. The line thus formed is fed from both ends of each furnace or cooling track.

CONTROL OF TEMPERATURES

Much of the outstanding success which has been experienced in the operation of the furnace is believed to have resulted from the satisfactory operation of the extensive system of temperature control which was selected and installed. In the control of temperatures and firing, each box position, or zone, is considered as a unit, and all zones are equipped alike.

Figure 4 — It is simple to connect the circuits from the five thermocouples inside the box to the recording and controlling pyrometers.

Thermocouples, upon which control of temperatures is based, are located both in the charges inside the boxes and in the combustion space between the box cover and furnace walls.

Figure 2 illustrates the manner in which thermocouples are mounted for detection of the temperatures of the work being annealed. The hot junction of one thermocouple is placed in contact with the side face of the pile of sheets or plates, as loaded, within six in. of each top corner of the load. Exploratory tests have

Figure 5 — Furnace and work temperatures are recorded and controlled by the instruments shown.

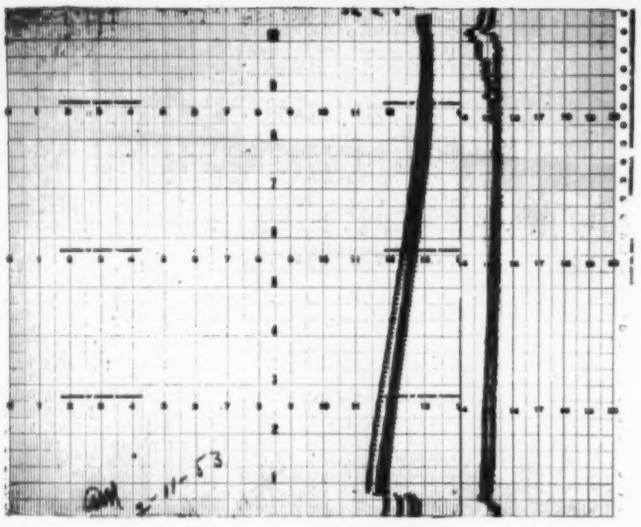


Figure 6 — Charts from No. 2 zone during one charge interval.

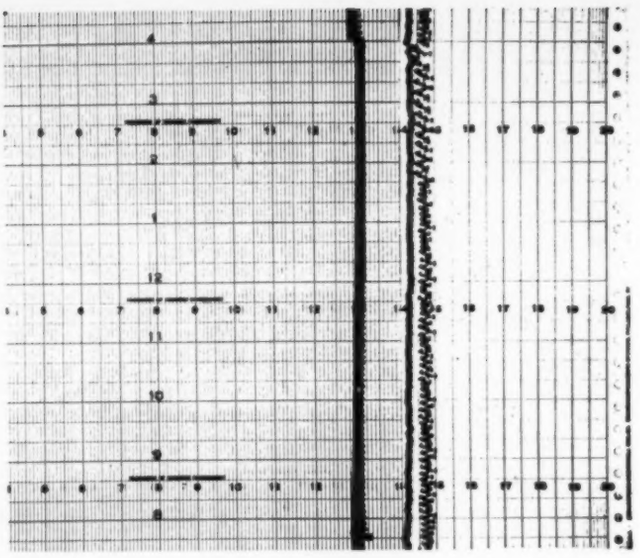


Figure 7 — Charts from No. 4 zone during one charge interval.

revealed that these positions consistently include the hottest spot in each charge. In addition to the four corner thermocouples, one is mounted under the load, as near its center as piling conditions will permit, to detect the temperature at the coldest position in the box. Circuits from these thermocouples are conducted through gas tight seals in the car bottom refractories to a terminal box on the under side of the car, shown in Figure 4. These circuits, then, are led, by means of the polarized plugs and receptacles shown, to the recording and controlling instruments. Sufficient cable is attached to the plug assembly to reach from one box position to the adjacent one. Proper operation of the equipment requires that all plugs be changed to succeeding boxes immediately after each furnace charge is made.

Thermocouples, encased in suitable protection tubes, are mounted through the furnace walls for detection of temperatures of the centers of the combustion chambers on each side of the furnace at each zone.

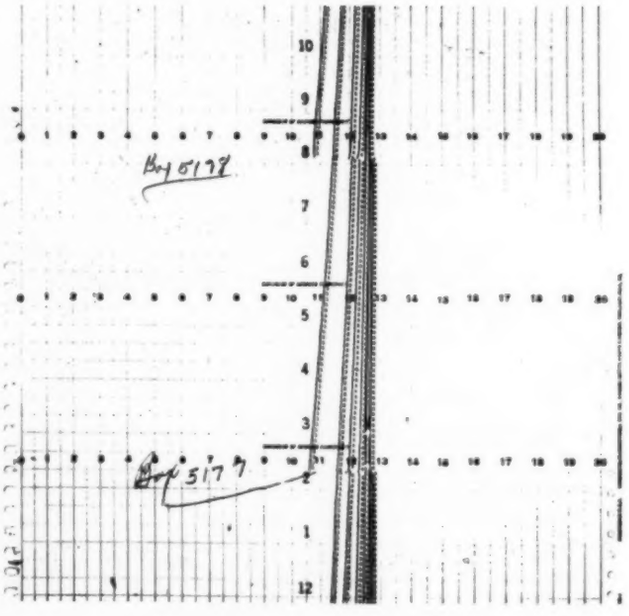
Recording and controlling pyrometers are installed in a control and meter house which is centrally located with respect to the entire installation of five furnaces. A view of the panel board is shown in Figure 5. Each vertically mounted pair of instruments records and controls the temperatures of one box, or zone. The instrument in each pair mounted in the upper position records the temperatures of the four corners of the charge in the box located in its zone in the furnace. The instrument in the lower position records the temperatures of the combustion chambers on each side of the box in the zone.

Control of temperatures is accomplished through simultaneous regulation of fuel and combustion air to all the burners on each side of each zone. Controlling circuits are so arranged that so long as the temperatures of the two thermocouples in the box on the one side of the furnace, and the temperature of the combustion chamber on that side, are below their respective set point positions, the fuel will be applied at the preset maximum rate. However, when any one of these points rises to a temperature above the set point, the fuel is reduced to the preset minimum. This action is effected by the arrangement of the control circuits from the three points involved in series, so that interruption of the circuit by any one of the points will de-energize the electric pneumatic relay controlling the air to the control valves.

These primary control valves are 3-in. butterfly valves in the combustion air line to the side of the zone, operated by motors. Gas is proportioned by zero governors, and proportioners, of sizes appropriate to the number of burners served. Relief dampers in the furnace roof are operated in synchronism with the control valves by motors.

The action of the controlling means is illustrated in the sections of chart shown in Figures 6 and 7. Charts from the two instruments on each zone have been matched for display to aid in explanation of the effect of the control action. During the interval of time spent by the box represented by Figure 6 in No. 2 zone of the furnace, the temperature of the corner of the charge inside the box came up to the set point. This tempera-

Figure 8 — Characteristic section of record of bottom of box temperatures.



ture took charge of the control, and it may be noted that the furnace temperature fell somewhat below its set point for the remainder of the period. The other side of the charge, however, failed to reach the set point on the zone, with the result that the furnace temperature on that side remained at its set point.

Figure 7 illustrates the uniformity of temperatures around all four corners of the charge which has been experienced from the type of control employed.

One six point recording pyrometer is devoted to the recording of bottom of box temperatures. A portion of a characteristic chart is shown in Figure 8. Flexibility of circuitry in this respect allows bottom temperatures to be recorded on any selection of six of the twelve boxes under fire. It is customary, however, to consider the temperatures of those boxes coming into the soaking period of the cycle to be significant, and the temperatures in those and the immediately preceding zones are recorded. Degree of uniformity of the bottom temperatures from box to box is quite clearly shown in the illustration.

Changes in annealing temperatures covering quite a wide range can be made on consecutive boxes with satisfactory results. Changes involving variation of total annealing time can be made only on the cycle of the longer time anneal.

This furnace, in its two year period of operation, has amply demonstrated its superiority over the portable bell type furnace of similar load capacity in a number of particulars. It has yielded a greater production rate at a lower rate of fuel consumption. No failures have been experienced requiring the rejection or reannealing of any portion of the product. Control is precise and reliable enough to give complete confidence in its performance with a minimum of attention from personnel assigned. A further advantage of the continuous furnace, not mentioned previously, will be of considerable value under some circumstances. The limited number of loading stations required will allow the coverage of a minimum area with overhead crane service.

The present intention is to rebuild and refurnish the older continuous furnaces with the improvements in construction and control incorporated in the new one whenever opportunity arises.

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MECHANICAL FEATURES
of Great Lakes 45x90-in. Universal Slabbing Mill

By PHILLIP C. VETTER
Chief Engineer
Great Lakes Steel Corp.
Ecorse, Detroit, Mich.

. . . . size, power and production are featured in the new slabbing mill at Great Lakes . . . .

▲ ON October 23, 1953, the Great Lakes Steel Corp. put into operation its new slabbing mill, consisting of its No. 3 stripper, No. 2 soaking pits, No. 3 universal slabbing mill, No. 4 slab yard, No. 13 motor room, crop and scale handling facilities, roll shop, offices and comfort stations.

The No. 13 stripper building is a continuation of No. 2 soaking pit building. The stripper building is 109 ft wide by 228 ft long, with one 400-ton stripper crane.

The soaking pits are housed in a pit building which is 109 ft wide x 456 ft long, with a 35-ft wide lean-to running the full length of the building. Six batteries of one-way fired recuperative soaking pits of the island type were installed. Each battery has four holes, 8 ft 6 in. wide x 25 ft 0 in. long x 12 ft 9 in. deep from the top of the pit to the coke breeze.

Each pit is equipped with one burner located in the end wall at the top of the pit. Fuel is burned above the top of the ingots, and the products of combustion are exhausted through ports in the burner end wall below the burner. The pits are fired with mixed blast furnace and coke oven gas, with a heat value of 385 Btu's per cu ft. The six batteries of pits have a capacity of 180,000 net tons per month when heating cold ingots to 2350 F.

The pits are provided with dual recuperation, con-

Figure 1 — Two 25-ton pit cranes with 35-ton auxiliary hooks handle the ingots.

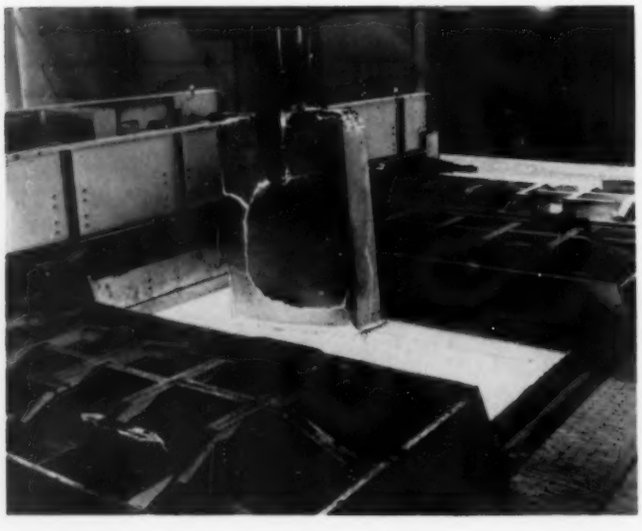


Figure 2 — The six soaking pit batteries have a capacity of 180,000 net tons when heating cold ingots to 2350 F.

Figure 3 — Ingot is shown in place on receiving table.

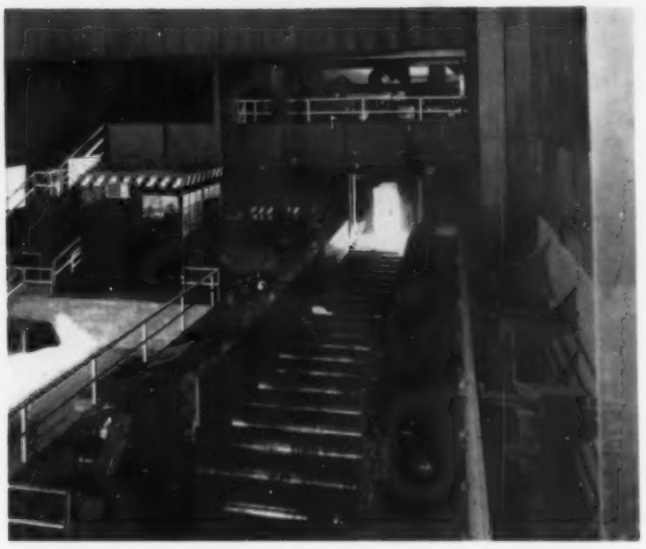


Figure 4 — Slab scale and turn-around is of the overhead type.

sisting of standard refractory tile recuperators and metallic tubular recuperators. The principle of operation involves the passing of the combustion air from a cold fan through the metallic recuperator at sufficient pressure and volume to entrain higher temperature air from the tile recuperator. The jet pump principle is used for this entrainment.

Each battery is provided with one 4300-cfm blower at 40-oz pressure. The pit covers are of the sprung arch type, lined with super duty refractories and insulated. Frames are of welded construction, using heavy plates and structural shapes.

Two 35-ton cover cranes, having a 49-ft span and a 6-in. lift, were installed to handle the covers.

One ventilated control house, located on the operating platform in the lean-to, is provided for each two batteries of pits and contains automatic control equipment for the pits.

Pit temperature controls, combustion air compensation controls, fuel air-ratio controls, flue draft controls, air and gas pressure controls, and recuperator high temperature limit controls are installed.

Two 25-ton soaking pit cranes, with 35-ton auxiliary hooks, are provided to handle the ingots.

Figure 1 shows a block of four pits, with an ingot in the crane tongs. The cover for the open pit can be seen suspended from the cover crane in the background.

Figure 2 is a general view of the soaking pit installation, looking from the mill toward the stripper building. The operating platform is to the left of the pits, and the ingot receiving track runs the full length of the pits between the operating platform and the pits.

The soaking pit crane delivers the ingots to a pot type ingot buggy operating on a standard gage track. The car is dumped by means of cams, and the ingot deposited on the receiving table. The ingot buggy is remote-controlled from the soaking pit operating floor, and it is automatically slowed down and stopped. The buggy has a maximum speed of 600 fpm.

In the basement, under the pits, cinder and debris are loaded into tractor-drawn dump cars, dumped into a skip pit, delivered by skip to an overhead bin, and then loaded into railroad cars. Coke breeze is delivered by conveyor and bucket elevator from a railroad track hopper to an overhead storage bin. From the storage bin the coke is discharged into bottom-dump hoppers handled by the pit crane.

Space is available for the addition of four batteries of four pits each, which will provide for an ultimate capacity of about 300,000 tons of ingots per month.

The 45 x 90-in. universal slabbing mill, and auxiliary equipment is located in a building 106 ft wide x 625 ft long. The finished slabs are delivered to the No. 4 slab yard which has a width of 106 ft and a length of 750 ft.

The slabbing mill installation consists of the following:

1—Ingot buggy.
1—Ingot receiving table.
1—Ingot turnaround and scale.
1—Mill approach table.
1—Front and rear mill table.
1—Slabbing mill.
1—Vertical edging mill.
1—Set of slabbing mill manipulators.
1—Mill runout table.
1—Hot scarfer approach table.
1—Hot scarfer.
1—Shear approach table.
1—2800-ton hydraulic shear.
1—Shear gage.
1—Crop conveyor.
1—Back shear table.
1—Slab scale.
2—Slab pushers.
2—Slab transfers for delivery of slabs to No. 4 slab yard.
1—Table at slab transfer and pilers.
4—Slab pushers for the pilers.
4—Slab pilers.

The ingot buggy delivers the hot ingots to the ingot receiving table, small end forward.

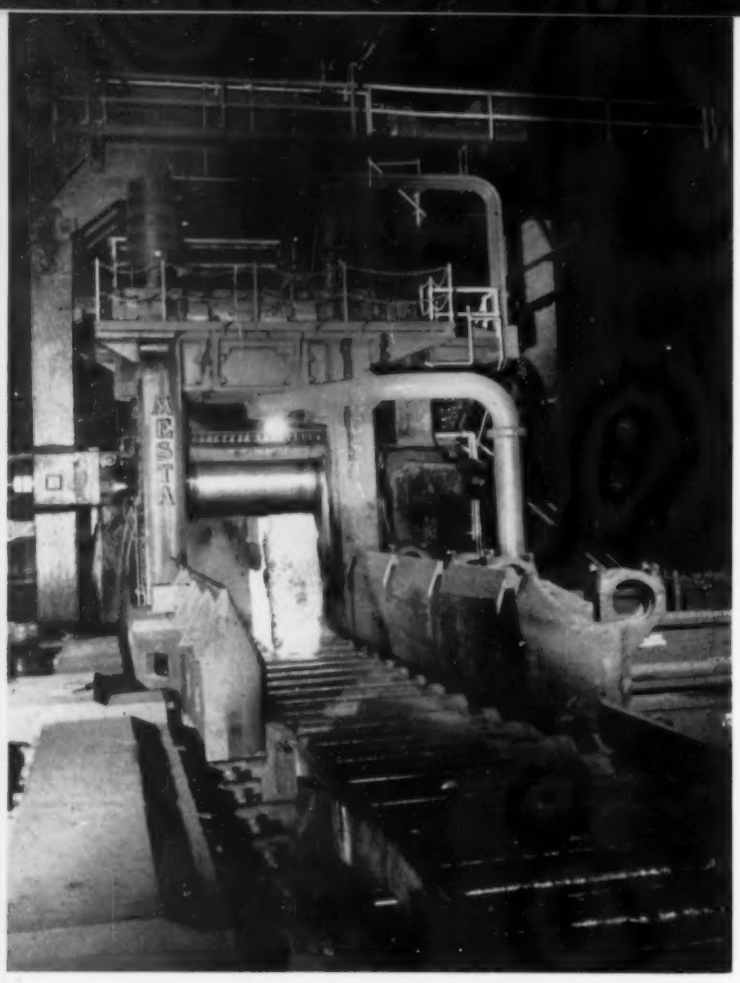


Figure 5 — Mill rolls open from 2¾ to 78½ in. maximum.

Figure 6 — The vertical mill has unusually high housings.

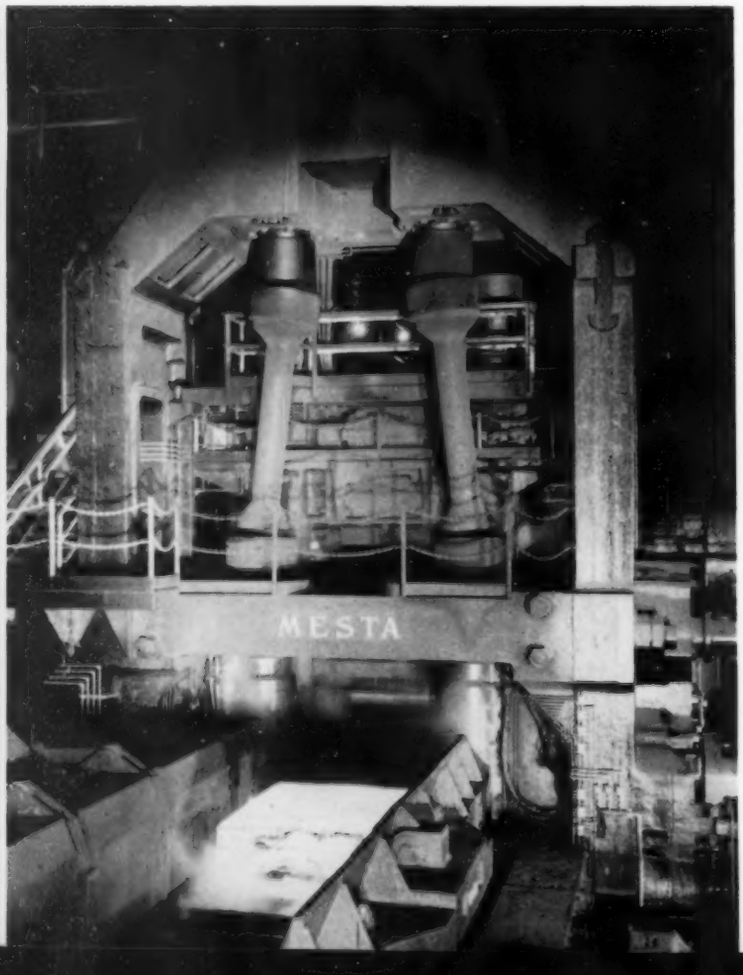


Figure 3 shows the ingot about to be delivered from the ingot buggy to the receiving table. This shows the soaking pits in the background. Figure 4 shows a view from the ingot receiving table, toward the mill. The ingot shown is on the slab scale and turnaround which is of the overhead type. The ingot is picked up and weighed and, if desired, can be turned 180 degrees for rolling the ingot butt-end first.

The scale house and operator's pulpit can be seen to the left of the ingot.

Figure 5 shows the 45 x 90-in. horizontal mill, with the ingot about to enter for the scale-breaking pass. The rolls of the horizontal mill are 45-in. diam x 90-in. long, and open from 2¾ to 78½ in. maximum, with the maximum diameter rolls in the mill.

Each roll is driven by two 3000-hp, 40 to 70-rpm, motors on a single armature shaft. This view shows clearly the side guides and the mill approach table.

While the horizontal mill housings appear to be small in this view, they are actually believed to be larger than any other similar housings built. In this view they are dwarfed by the height of the frame supporting the drive gears for the vertical mill rolls.

One of the main features of the slabbing mill is that the vertical rolls can be changed without dismantling the mill or drive.

The roll balance is of the counterweighted type. A selsyn-operated dial indicator, located in the operator's pulpit, shows the opening between the horizontal rolls.

Figure 6 shows the vertical mill as seen from the operator's pulpit. This view shows the high vertical mill housings, with the vertical rolls, roll spindles; and, at top left, can be seen the vertical roll drive shaft. The horizontal top roll can be seen through the opening of the vertical rolls. The side guards are shown in the foreground. Note the fingers for turning the ingots, in the left guard. These are the only finger manipulators furnished with this mill.

The vertical mill rolls are 37 in. diam, with 96-in. long body and 72-in. face, and open from 24 to 90 in. The rolls are driven by two 2000-hp, 60 to 150-rpm, motors on a single armature shaft, through bevelled gears and flexible type spindles.

A selsyn-operated dial, which indicates the opening between rolls, is located in the operator's pulpit. The operator's pulpit is located about 62 ft from the vertical mill.

The first pass is made with the horizontal roll, with the ingot on edge for breaking the scale.

Typical rolling schedules are as follows:

1. 26 x 82 x 80-in. long ingots are rolled to 4¼ in. thick x 76½ in. wide slabs with 21 horizontal roll passes and 4 vertical roll passes.
2. 25 x 78 x 91 in. long ingots are rolled to 4½ in. thick x 75¾ in. wide slabs with 19 horizontal roll passes and 4 vertical roll passes.
3. 25 x 72 x 91 in. long ingots are rolled to 4½ in. thick x 69½ in. wide slabs with 19 horizontal roll passes and 3 vertical roll passes.
4. 32 x 78 x 88 in. long ingots are rolled to 4½ in. thick x 74¼ in. wide slabs with 26 horizontal roll passes and 8 vertical roll passes.

Figure 7 — Ingot shown is about to enter the horizontal rolls.

Figure 8 — Two operators are used on the mill.

Figure 7 shows side view of the vertical mill. The horizontal mill can be seen just to the right of the vertical mill housing. The ingot shown is about to enter the horizontal rolls.

In Figure 8 are shown the slabbing mill operators and the two selsyn-operated dials which indicate the width and thickness of the slab. The chief operator controls the screwdown, front and rear mill tables, runout table, and the motors for horizontal and vertical drives. The assistant operator controls the vertical mill adjustment, the manipulator, and the side guides.

After rolling, the slab is delivered to the hot scarfers, where the slab is hot scarfed, removing from $\frac{1}{32}$ to $\frac{1}{8}$ in. from top and bottom of the slab surface, at a speed of from 80 to 160 fpm. This scarfer is equipped with 144 nozzles, of which 132 are used to scarf a 76-in. wide slab. When narrower slabs are being scarfed, part of the nozzles are closed off.

A side view of the hot scarfer is shown in Figure 9, with the operating pulpit and repair shop in the rear. A narrow roll in front of the scarfer, the stall bloom device, automatically shuts off the scarfer, if the slab stops during the scarfing operation. Figure 10.

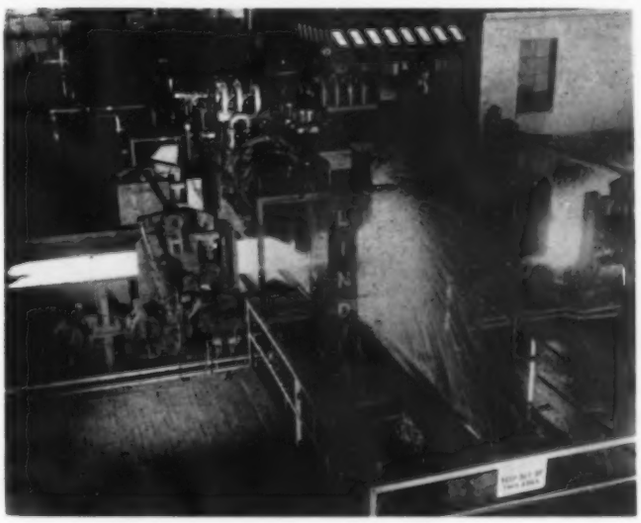


Figure 9 — A stall device is used with the scarfer to shut it off if the slab stops during the operation.

Figure 10 — Flexible connections are provided for all services to the scarfer.

Another view of the scarfer shows the discharge end. Flexible connections are provided for all services to the scarfer, since it must be retracted to remove and service the burner tips.

From the hot scarfer, the slab is delivered to the 2800-ton hydraulic upcut shear which has a capacity to shear slabs 12 in. thick x 76 in. wide, a total area of 912 sq in. The hydraulic pumps and controls are located in the basement and are designed to operate at a pressure of 2500 psi. Figure 11 shows the shear and gage. Minimum slab lengths of 3 ft 9 in. and maximum lengths of 20 ft 9 in. are handled by the shear gage. The slab crops are delivered by conveyor to the crop pit, from which they are loaded by overhead crane and magnet to railroad cars. Two slab pushers and slab transfers deliver the slabs to the runout table in No. 4 slab yard.

Figure 12 shows a slab being delivered from the shear to the first of two slab pushers which push the slabs onto the transfer to No. 4 slab yard. The shear operator's pulpit can be seen at the right. The large cylin-

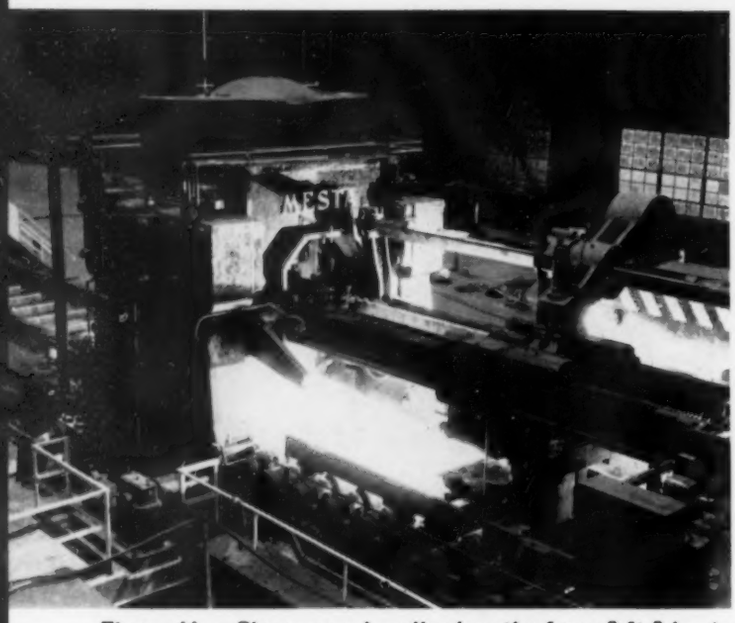


Figure 11 — Shear gage handles lengths from 3 ft 9 in. to 20 ft 9 in.

der at the left is the accumulator for the shear hydraulic system.

The two pushers and the two transfers which deliver the slabs to the No. 4 slab yard are shown in Figure 13. The slab transfer consists of a series of parallel rails and chains. A series of dogs are mounted on the chains which slide the slabs across the transfer.

In No. 4 slab yard, four pushers are provided to push the slabs onto four pilers which have vertical motor-driven screw lifts. When the piles are formed, the motor-operated dragoff bars remove the piles onto skids, thus permitting the forming of an additional pile without delay.

Scale runs are provided under the slabbing mill and under all tables from the ingot receiving table to the shear. The scale runs are lined with steel castings and are paralleled by a continuous walkway. A continuous lift beam is provided over the walkway on both sides of the mill, so that large chunks of scrap can be delivered by trolley-mounted hooks to scrap pits located on the entry and discharge side of the mill. From the scrap pits the scrap is removed by the overhead mill crane.

Figure 13 — Slab transfer consists of a series of parallel rails and chains.

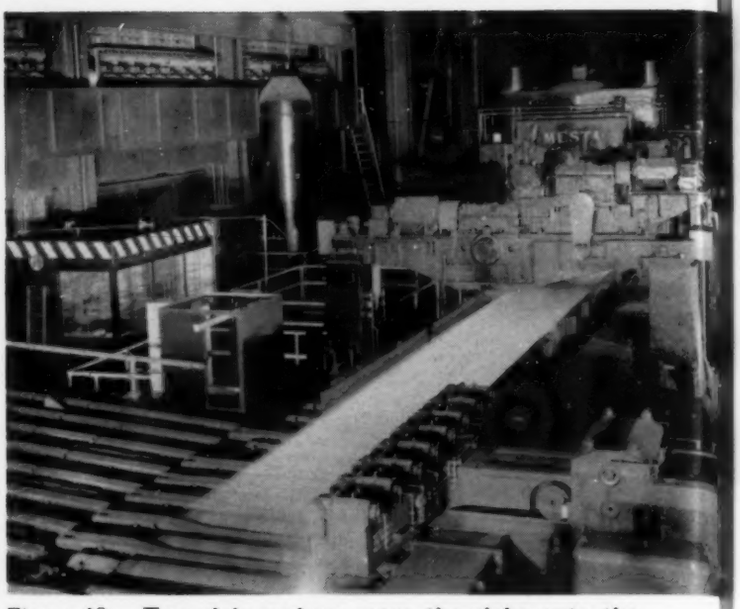


Figure 12 — Two slab pushers move the slabs onto the transfer to No. 4 slab yard.

The scale runs discharge into a primary scale pit located near the slabbing mill. This pit is 60 ft long x 10½ ft wide x 35½ ft deep, below the mill floor. A second scale pit is provided in No. 4 slab yard to take care of scale from the slab transfer, table and pilers. Water from this pit flows through a sewer to the primary scale pit at the mill. From the primary scale pit, the water flows through a 48-in. diam sewer to the secondary scale and oil skimming basin located outside of the mill building. This pit is 66 ft long x 16 ft wide x 32½ ft deep, below yard level. The pit is provided with an oil skimmer, and a pump for pumping the oil to a settling tank, where the water is decanted and returned to the pit. The collected oil is dumped into the fuel oil storage system.

Due to the depth of the secondary scale pit, it is necessary to pump the water to the plant sewers. For this purpose, three motor-driven, 7500-gpm pumps were installed without automatic control, to hold the water in the scale pit at a constant level.

DISCUSSION

PRESENTED BY

PAUL E. LINDBERG, JR., Superintendent Hot Metal Div., McLouth Steel Corp., Trenton, Mich.

CECIL R. GINGERICH, Engineer, Linde Air Products Co., Detroit, Mich.

Paul E. Lindberg, Jr.: I have one question on the scarfing machine. Is the depth of the cut governed by the speed of the mill?

Cecil R. Gingerich: Yes, the depth of cut is a function of both the speed and the cutting oxygen pressure. It is more desirable, however, to control the depth of cut by varying the speed and using a more constant oxygen pressure. Too high a cutting oxygen pressure is likely to produce a poor blending of the cuts between the nozzles. At most installations, a cutting oxygen pressure of 30 to 35 psig is used and the depth of cut is controlled by varying the speed of the tables.

ELECTRICAL FEATURES

of Great Lakes 45x90-in. Universal Slabbing Mill

By HAROLD C. HOEFT
Assistant Chief Electrical Engineer
Great Lakes Steel Corp.
Ecorse, Detroit, Mich.

. . . . electrical equipment is teamed up with the mechanical equipment to get maximum output from the mill . . . .

▲ THE new 45 × 90-in. universal slabbing mill at Great Lakes Steel Corp. is one of the highest-powered mills of its type in the world. It employs some 21,500 horsepower of motor capacity, to carry the ingots from the soaking pits up to the mill, process the ingots—including rolling and scarfing, and transport the finished slabs to the slab pilers. Of this 21,500 horsepower, approximately 2500 hp represents constant voltage direct-current motors of the standard 600 series mill type; some 3000 hp represents variable voltage direct-current motors of the standard 600 series mill type; and the remaining 16,000 hp represents the variable voltage direct-current reversing motors driving the horizontal and vertical rolls of the mill proper.

In addition, over 14,500 hp of a-c motors are required for driving the a-c to d-c power conversion motor-generator sets, the various hydraulic and lubrication pumps, and the ventilating fans.

In order to supply the needs of the variable voltage direct-current motors, 16,700 kw of direct-current generating capacity has been provided. This does not include some five main drive field exciters, three constant potential exciters, and twenty-five rotating regulating exciters.

The needs of the constant voltage direct current motors, in addition to other shop requirements, have been met by the provision of 3000 kw of ignitron rectifier capacity. This gives an idea of the very large amount of electrical equipment associated with this mill. The principal objective of this discussion will be to describe how this equipment is employed, and how it is controlled.

MAIN DRIVE

The horizontal rolls are individually driven by 6000-hp, 40/70-rpm, 700-volt, d-c, double-armature, direct-connected, reversing motors (Figure 1).

One motor drives the top roll, and one drives the bottom roll, to form a 12,000-hp twin drive. The frequently-repeated maximum torque capacity of this drive is 3,540,000 lb ft, and this represents the setting of the current limiting apparatus. The occasionally-repeated maximum torque capacity is 4,330,000 lb ft, and this represents the setting of the circuit breakers in the motor armature circuits.

Each motor is provided with two pedestal-type, oil-ring lubricated, split sleeve bearings. A heavy duty thrust bearing is provided on the coupling end pedestal, and a light duty thrust bearing with oscillation damper is provided on the opposite end pedestal.

Each horizontal 6000-hp motor weighs 312 tons—the armatures weighing 107 tons, mounted on a single shaft.

The vertical rolls are driven through right angle

Figure 1 — Horizontal rolls are driven by two 6000-hp motors.

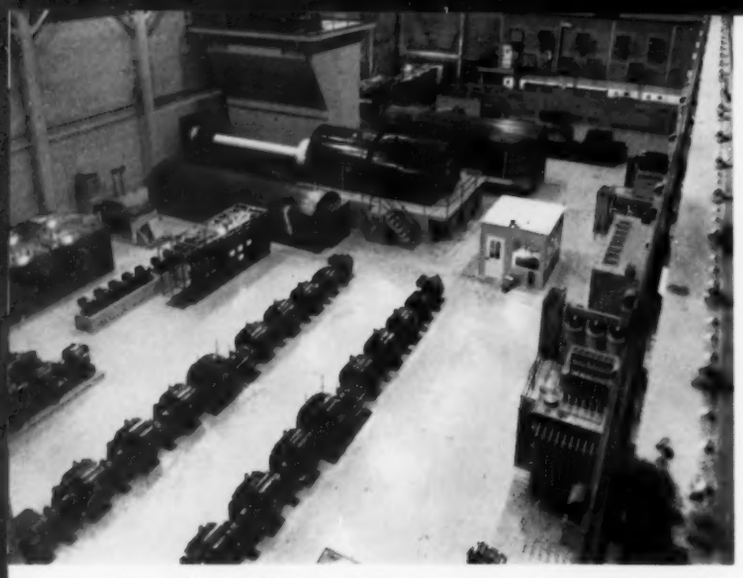


Figure 2 — A 4000-hp, double-armature motor drives the vertical rolls.

Figure 3 — A 13,500-kw, 8-unit flywheel motor-generator set furnishes d-c power for the main roll drives.

reduction gears by a 4000-hp, 60/150-rpm, 700-volt, d-c, double-armature motor (Figure 2). This motor weighs 166 tons and is located 33 ft 6 in. above the motor room floor, on a steel-reinforced concrete base. Double armature construction was used to minimize the armature diameter and permit close spacing of the various roll drives.

Direct current power for the complete 16,000 hp drive is supplied by a 13,500-kw, 8-unit flywheel motor-generator set, (Figure 3) consisting of four 2500-kw, 700-volt generators for the horizontal roll drives; two 1750-kw, 700-volt generators for the vertical roll drives; a 9000-hp, 514-rpm, 6900-volt, 3-phase, 60-cycle, wound-rotor induction motor; and a 128,000-lb steel plate flywheel having a stored energy of 215,000 hp-sec at 514 rpm.

A liquid type slip regulator has been provided for the secondary control of the 9000-hp induction motor. See Figure 4.

Arrangement of the armature and field circuits of the main drive is shown in Figure 5.

The armatures of the three roll drives, the top and bottom horizontal rolls and the vertical rolls, are connected in three separate series loops, consisting of two motor armatures and two generators interposed so that the voltage to ground is the voltage across one armature only. This arrangement has a number of advantages over one involving the paralleling of armatures. The number of circuit breakers required is reduced and the possible short circuit current is minimized. Load balancing is eliminated, except for that required between the loops associated with the top and bottom horizontal rolls.

All of the main drive machines are shunt wound, and the field circuits are energized from adjustable voltage exciters, as shown. Two exciters are used in the field circuits of the horizontal top and bottom roll drives, to permit the use of small, fast response machines.

The exciters are controlled by rotating regulating exciters which perform the following functions:

1. Voltage regulation of the generator voltage, with respect to the position of the foot-operated master switch.
2. Current regulation of the motor fields, with respect to the position of the foot-operated master switch.
3. Current limit regulation of the motor armature circuit by motor field control to prevent the occurrence of excessive current, as a result of either rapid changes in motor speed or undue rolling load in the field weakening range.

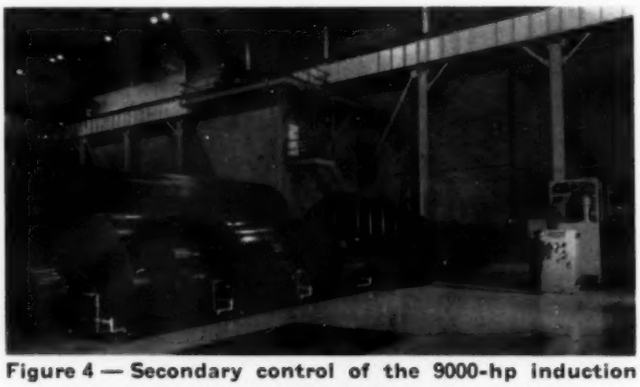


Figure 4 — Secondary control of the 9000-hp induction motor is provided by a liquid type slip regulator.

Under full field conditions, excessive armature current resulting from rapid changes in motor speed is prevented by generator voltage control.

4. Load balance regulation, to insure the proper division of load between the top and bottom horizontal rolls.

Figure 5 — Schematic diagram shows main circuits and field circuits of slabbing mill drive.

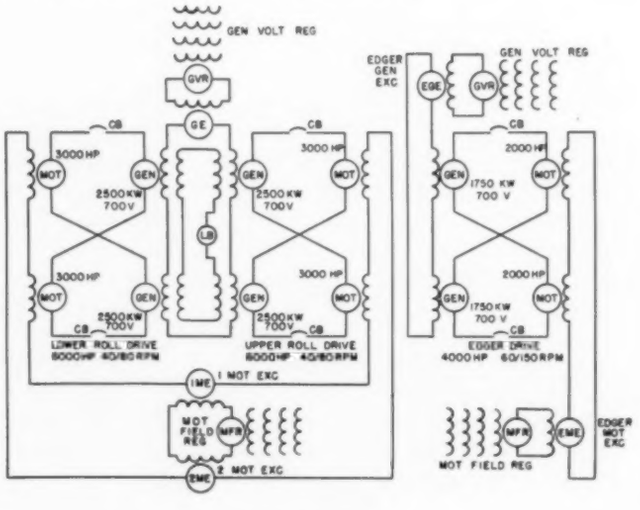


Figure 6 — Foot-operated master switches control speed and direction of rotation of both sets of rolls.

The foot-operated master switch permits the operator to control the speed and direction of rotation of both sets of rolls in unison. See Figure 6. The switch is provided with six points. The first set of three points successively increases the generator voltage with the motor at full field; and the second set of three points successively weakens the motor field with the generator at constant voltage.

The voltage regulator can be adjusted for a reversal from base speed in one direction, to base speed in the opposite direction in 1.0 second. This is somewhat fast, and it has been found that a reversal time of 1.5 sec is better suited to normal operations, because of the practical limitation imposed by the mill, ingot and motor inertias and the natural reflexes of the operators.

Figure 7 shows the response curves of the excitation system for generators of the slabbing mill, when adjusted for 1.5 sec reversal time. If, during acceleration at constant motor field, the draft taken is so large that the motor current exceeds 225 per cent, the rate at which the generator voltage is increasing will be decreased by means of the generator current limit control.

If the motor current exceeds 225 per cent at any time that the motor field is weakened, the motor field will be strengthened. Under no condition, however, can the motor field be increased above its rated full field value. The acceleration from base speed to top speed is accomplished at the maximum rate permitted by the current limit circuits.

The heavy sections which are normally rolled in this mill can transfer a considerable amount of power between the horizontal and vertical rolls. To insure that the edger takes no more than its share of the total load, the edger drive is provided with a drooping speed characteristic. Means are provided for recalibrating the field setting of the edger motor to compensate for variations in the mill and edger roll diameters.

In addition, a rheostat is provided for adjusting the speed of the edger motor by shunt field control, when the slab is passing from the vertical rolls into the horizontal rolls, to compensate for the reduction taken in the latter.

A mill selector switch having three positions—"Creep," "Suicide," and Jog" is provided. The first

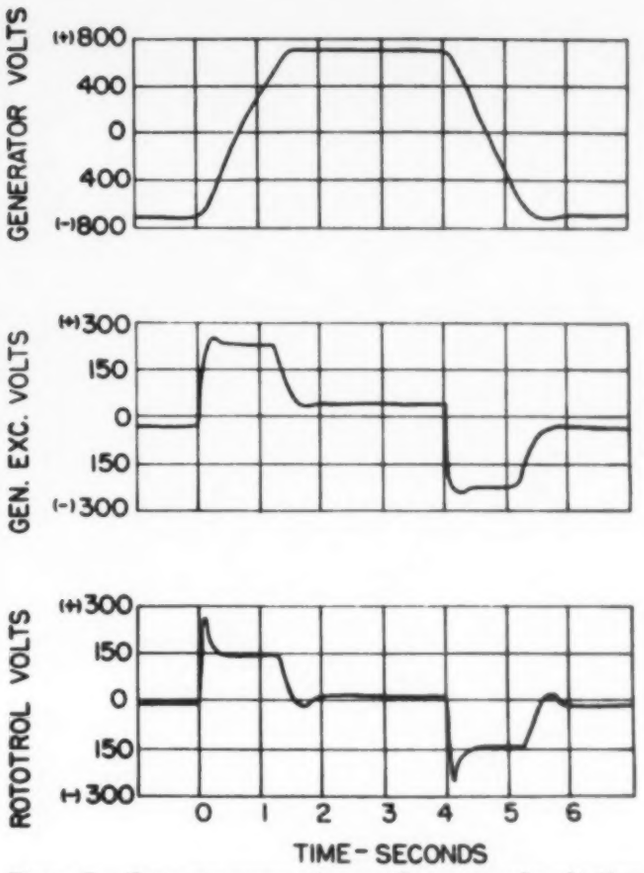


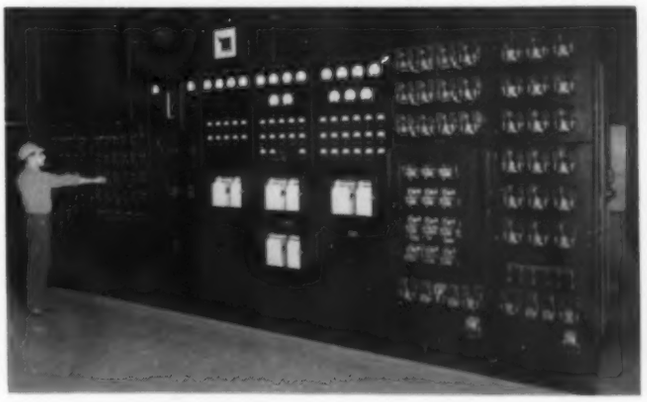
Figure 7 — Response curves show performance of excitation system.

two positions set the control circuits up for normal operation by means of the foot-operated master switch. In the first position, the mill will creep in the reverse direction, and in the second position the mill will come to a dead stop when the master switch is returned to the "Off" position. In the "Jog" position, the control circuits are set up to permit jogging which is done from a control cabinet at the mill. This provides a very flexible control arrangement.

The control has been designed so that, in the event of a failure of one of the four main drive generators or one armature of either main mill drive, a removable bus section can be interchanged so that the mill can still be operated at reduced capacity. The edger can be reconnected also, to run at reduced capacity in the event of failure of one generator or one motor armature.

Figure 8 shows the main mill drive control board.

Figure 8 — Control board for main roll drive.



AUXILIARY DRIVES

The basic circuit for the adjustable voltage drives for manipulators, mill tables, feed rolls, horizontal roll screwdowns and vertical roll adjustment is shown on Figure 9. These controllers have been designed to regulate the generated voltage to provide the desired operating speed, and to permit rapid acceleration and deceleration without excessive current. The auxiliary generators are special 250-volt machines designed for a maximum light load voltage of 600 volts.

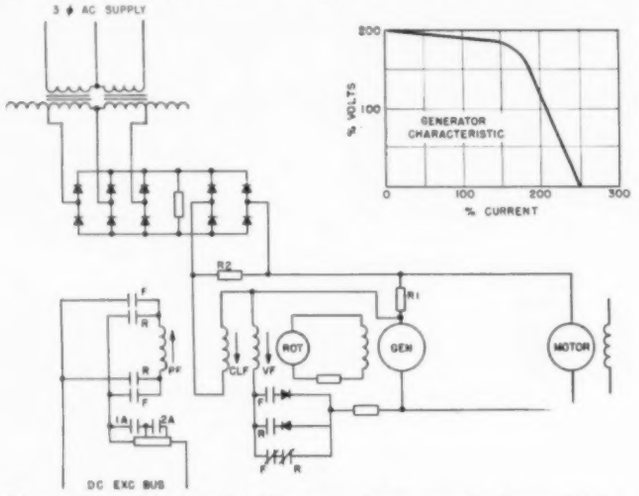


Figure 9 — Schematic diagram shows control for adjustable voltage auxiliaries.

When used in conjunction with the controllers, the voltage is made to droop slightly with load. At about 150 per cent load, the voltage is made to drop off rapidly as the load is further increased, until, at 250 per cent load, the voltage is made equal to the external IR drop. These characteristics, together with the fast response of the voltage regulating system, provide the maximum rate of acceleration and deceleration without damage to the motor.

The variable voltage auxiliary drives are supplied from two identical 10-unit synchronous motor-generator sets. (Figures 10 and 11). The units are arranged so that the mill can be operated at reduced capacity, if one of the set driving motors should fail. For emergency operation, with one generator out of service, the two mechanically-connected motors making up each complete drive for the front and rear mill tables, the entry and delivery feed rolls, left and right manipulators, and the right and left screwdowns will be connected in series and operated from the remaining generator.

Although it is usual practice to mechanically or electrically couple the vertical roll adjustment drives, so that the rolls are kept at equal distances from the centerline of the mill, it was not done in this installation. The rolls are adjusted by individual motors operating in unison but without a connecting tie. A differential synchroindicating system is used to show when either roll is out of alignment. This drive arrangement has proved very satisfactory, the errors in alignment being negligible.

Under emergency operation, with one generator out of service, the two motors making up this drive must be connected in parallel, rather than in series, and operated from the remaining generator. For emergency operation, with the finger drive generator out of service, the finger motor will be transferred to the shop constant potential supply and be operated from a standby controller provided for this purpose. For emergency operation, with the ingot buggy generator out of service, the generator will be used to supply the ingot buggy, and the finger will be operated from the standby controller.

Two generators normally supply the six motors driving the six feed rolls. Under emergency operation, with one generator out of service, all of the feed roll motors will be operated in parallel from the remaining generator. Every precaution has been taken to insure the continuity of operation of the mill.

Four table sections are used in conjunction with the automatic scarfing machine. These are identified as the mill runout table, the scarfer approach table, and the shear approach tables—sections 1 and 2. Each section is driven by a variable voltage mill motor supplied from an individual adjustable voltage generator.

The four generators make up a 5-unit induction motor-generator set. Each generator is excited by a rotating voltage regulating system similar to that previously described. For scarfing operation, the rotating regulators act as counter EMF regulators, to hold the motor speed essentially constant with load. A selector switch is provided for either independent operation of the table section from separate master switches, or scarfing operation involving either just two or all sections, depending on the length of slab to be scarfed.

Figure 10 — Two 10-unit synchronous motor generator sets supply the variable voltage auxiliary drives.

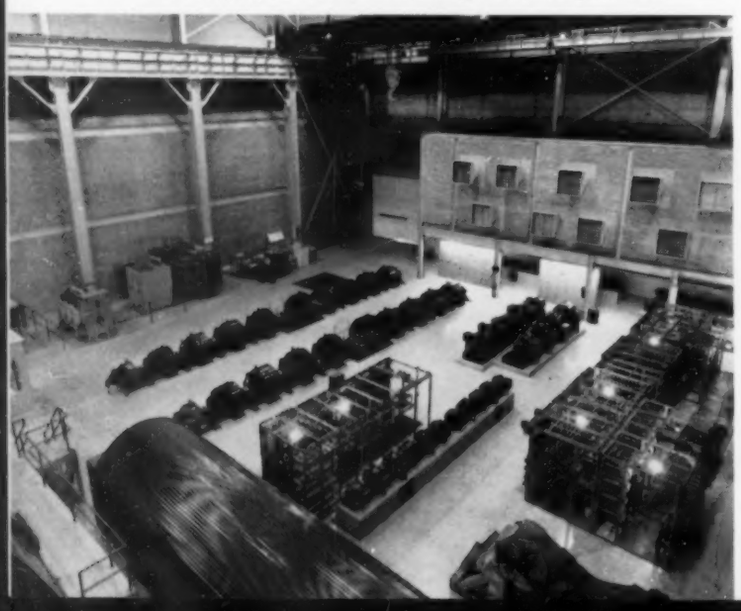
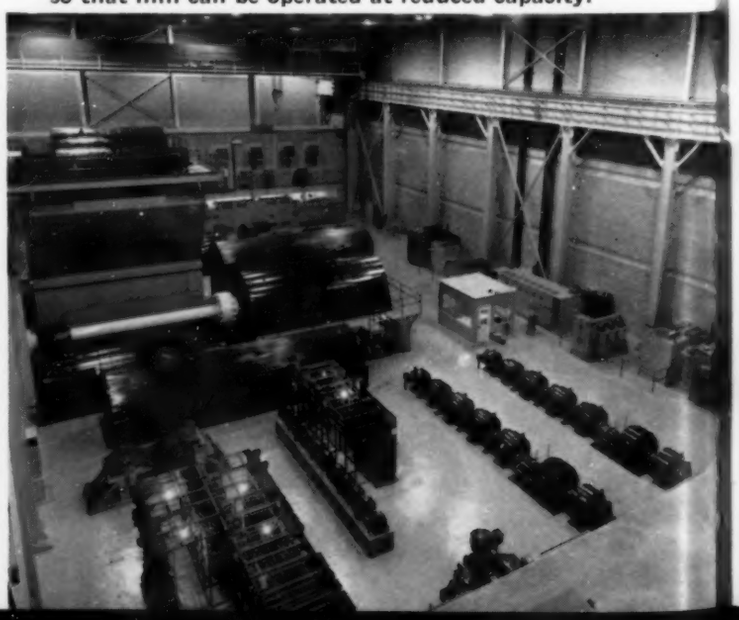


Figure 11 — Variable voltage auxiliary drives are arranged so that mill can be operated at reduced capacity.



The table speed for scarfing can be set by the operator, by means of a rheostat in the scarfer pulpit.

MILL POWER SUPPLY

Power is supplied to the mill from two 10,000-kva, 6900-volt, 3-phase, 60-cycle transformers by two feeders.

The feeders are brought into the motor room through an indoor metal-clad switchgear structure consisting of 16 units housing 500,000-kva interrupting capacity circuit breakers and auxiliary equipment for controlling the incoming line circuits, the 9000-hp induction motor driving the main flywheel motor-generator set, the two 1250-hp synchronous motors driving the auxiliary motor-generator sets, two 2500-kva power centers, and two 1500-kw rectifiers.

POWER CENTERS

Low voltage a-c power is distributed from two indoor power centers mounted side by side in the motor room. Each power center is made up of a 2500/3333-kva, AA/FA, 6900/480-volt, 3-phase, 60-cycle, dry-type transformer close coupled to an indoor low voltage metal-enclosed switchgear structure.

The switchgear structure houses the transformer secondary circuit breakers, a tie circuit breaker for supplying both of the low voltage buses from one transformer in case of an emergency, feeder circuit breakers for the control centers (of which there are four), general mill power east and west, the exciter and scarfer motor-generator sets, and the various auxiliaries associated with the scarfer and the hydraulic shear, such as the 150-hp scarfer exhaust fan, the three 400-hp shear hydraulic pumps, and the two 300-hp high-pressure water pumps for the scarfer. These drives are all arranged for full voltage starting.

RECTIFIER

The constant voltage power requirements of the mill are supplied from two 1500-kw, 250-volt rectifiers, each consisting of a 1500-kw, 6900-volt, 3-phase, 60-cycle, inerteen-filled, self-cooled, rectifier power supply transformer; six ignitron tubes, complete with necessary vacuum maintaining and indicating equipment; an auxiliary control transformer and control cubicle; water-to-water heat exchanger; and metal-enclosed anode switchgear unit.

A 10-section low voltage metal-enclosed switchgear structure houses the equipment for the control of the paralleled circuits of the two rectifiers, including two cathode circuit breaker sections, six feeder circuit breaker sections, and two control sections.

VENTILATION EQUIPMENT

The No. 13 motor room, which is of steel and brick construction, is well-lighted and is provided with clean ventilating air by means of two 224,000-cfm, continuous, semi-automatic electrostatic air cleaners. Normally, outside air is drawn into the motor room through each precipitator by nine 25,000-cfm axial flow fans, although, in cool weather, provision is made for recirculation. The air is pulled through the flywheel motor-generator set by four 37,250-cfm centrifugal fans, pulled through the main mill motor and the edger motor by three 63,400-cfm centrifugal fans, and through the auxiliary motor-generator sets by one 30,000-cfm centrifugal fan.

Air is delivered to the auxiliary variable voltage drives in the mill area by three 13,390-cfm centrifugal fans.

The intake fresh air fans are provided with automatic outlet dampers, and the distribution fans are provided with manually-operated outlet dampers. Thus, any fan may be shut down, independently.

At times in the past, on previous mills, the production people have felt that more steel could be produced, if more power were available. The record capacity installed in our 45 × 90-in. universal slabbing mill installation, together with the rapid reversal of the main mill drive, the rapid response of the mill auxiliaries, and emphasis on continuity of operation throughout the installation by providing emergency alternatives, should leave little doubt that the mechanical and electrical equipment are teamed-up to yield the maximum output.

DISCUSSION

PRESENTED BY

E. R. VILLAIRE, Application Engineer, Arthur B. Sonneborn Co., Detroit, Mich.

HAROLD C. HOEFT, Assistant Chief Electrical Engineer, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

ROBERT B. REED, Application Engineer, Reliance Electric and Engineering Co., Detroit, Mich.

C. F. CAMPBELL, Field Engineer, Elliott Co., Detroit, Mich.

LOREN F. STRINGER, Steel Mill Engineer, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

C. M. SMITH, Chief Engineer, Rotary Electric Steel Co., Detroit, Mich.

G. A. CALDWELL, Manager, Detroit Engineering Dept., Westinghouse Electric Corp., Detroit, Mich.

E. R. Villaire: Will you please give us some additional information on the ingot buggy control?

Harold C. Hoeft: The ingot buggy is variable voltage controlled and is master switch operated from the operator's station located on the soaking pit lean-to balcony. However, with slowdown and a stop limit switch, the loaded ingot buggy is prevented from entering the unloading ramp. The operator in the ingot turnaround pulpit brings the buggy the rest of the way.

Therefore, the control of the ingot buggy is accomplished by use of master controllers, limit switches and sectionalized rails in conjunction with control panels located in No. 13 motor room.

Robert B. Reed: Is there any provision for stopping the main 13,500-kw motor-generator set in case you lose a bearing or some other mechanical failure occurs? It looks like it will roll forever.

Harold C. Hoeft: When the 13,500-kw motor-generator set is stopped under normal conditions it takes approximately one hour plus for it to come to a standstill. However, when emergency arises and it becomes necessary to stop this set in a hurry, dynamic braking is applied. If the selector switch is set on dynamic braking, as soon as the motor-generator set

circuit breaker is knocked off the line, the dynamic braking circuit breaker is closed, these breakers being mechanically interlocked, and low voltage, high amperage are applied into the high voltage stator winding of the 9000-hp induction drive motor, causing the set to come to a complete stop in approximately three minutes. This dynamic braking current is produced by a 41.7-kw, 50-volt dynamic braking generator located in No. 13 motor room.

C. F. Campbell: What is the synchronous speed of the wound-rotor motor, and how do you hold a constant speed on the generators with a wound rotor motor? The big flywheel is a help, but I should think the generators would require a more constant speed than the flywheel can hold, considering the shock loads involved.

Loren F. Stringer: The answer to Mr. Campbell's question as to how we maintain the speed of the main mill generators at 514 rpm when they are driven by a wound rotor induction motor is quite simple. We do not. The principal reason for using an induction motor drive is that the motor speed does decrease as load is applied, and, therefore, a part of the load will be carried by the flywheel. The total rotational energy stored in the set including the flywheel is some 264,000 hp sec at 514 rpm. If the speed of the set decreases as much as 15 per cent, some 74,000 hp sec will be removed from this storage and supplied to the load. The speed reduction is implemented by a liquid slip regulator which increases the secondary resistance of the motor when the load drawn from the a-c line exceeds some predetermined amount. This more or less smooths out the power peaks drawn from the a-c system as a result of the high intermittently applied loads that are characteristic of reversing mills.

C M. Smith: I understood Mr. Hoeft to say it is possible to get reversal from base speed forward to base speed reverse in one second. I would like to ask if this has been actually achieved with instruments and also why it was desirable to back off through to one and one half second reversal. Is there some technical reason why this isn't satisfactory?

G. A. Caldwell: We have a similar mill in service where much emphasis was put on reversing time and the mill is now reversing from base speed forward to base speed reverse in one second. An oscillogram showing these results is on page 63 of the October 1953 issue of the Iron & Steel Engineer.

On the Great Lakes mill where there is very little turning of the slab, no particular issue has been made in regard to reversing time, and it seems unnecessary to reverse faster than 1.5 sec. In fact, the drive was initially adjusted for approximately 1.25 sec and the reversing currents were only slightly over the full load value. The operators felt that the reversal was too fast and consequently the time was increased as indicated.

If in the future, they desire shorter reversing time, in an effort to increase tonnage or for other reasons, it can be done by a simple adjustment in the control circuits.

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CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, March 28, 1955 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"My Trip to Japan and Korea," by R. D. Osgood, Retired Chief Engineer, Tennessee Coal and Iron Div., United States Steel Corp., Fairfield, Ala.

Thomas Jefferson Hotel, Birmingham, Ala.

BUFFALO SECTION

Tuesday, March 8, 1955 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Metallurgical Aspects of Rolling Seamless Tube Mill," by Clay Crawford, Assistant Superintendent of Seamless Tube Mill, Colorado Fuel and Iron Corp., Pueblo Works, Pueblo, Colo.

Hotel Sheraton, 715 Delaware Avenue, Buffalo, N. Y.

CHICAGO SECTION

Tuesday, March 1, 1955 — Dinner 6:15 P.M., Meeting 7:45 P.M.

"A Report on the Replacement of Inland Steel Co.'s No. 2 Blooming Mill," by A. L. Schroeder, Assistant Chief Engineer, Inland Steel Co., East Chicago, Ind.

Phil Smidt's Restaurant, 1205 N. Calumet Avenue, Hammond, Ind.

CLEVELAND SECTION

Tuesday, March 15, 1955 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Special Design Requirements of Steel Mill Trailers," by J. A. Draxler, Manager of Service and Field Engineering, The Elwell-Parker Electric Co., Cleveland, Ohio.

University Club, 3813 Euclid Ave., Cleveland, Ohio.

DETROIT SECTION

Tuesday, March 8, 1955 — Dinner 6:30 P.M., Meeting 8:00 P.M.

"Continuous Pouring of Steel," by Isaac Harter, Jr., Supervisor, Continuous Casting, Babcock and Wilcox, Tube Div., Beaver Falls, Pa.

Parlors E, F and G, Horace Rackham Educational Memorial, Detroit, Mich.

LOS ANGELES SECTION

No meeting scheduled.

PHILADELPHIA SECTION

Saturday, March 5, 1955 — Dinner 6:00 P.M., Meeting 7:00 P.M.

"Problems Involved in the Erection of a Modern 28 ft 9 in. Hearth Blast Furnace on the Site of Old 19 ft 0 in. Furnace," by J. F. Zeigler, Blast Furnace Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Plastic Pipe," by George C. Anderson, Assistant Manager, Future Planning and Development, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

Engineers' Club, 1317 Spruce Street, Philadelphia, Pa.

Tuesday, March 8, 1955 — Meeting 2:30 P.M.

"Safety in a Steel Plant," by E. D. Morgan, Superintendent, Plant Protection and Safety, Bethlehem Steel Co., Bethlehem, Pa.

"Engineered Safety Features at Fairless Works," by H. S. Spitz, Chief Engineer, Homestead Works, United States Steel Corp., Munhall, Pa.

This is a joint meeting with the 21st Annual Regional Safety Conference, Broadwood Hotel, Philadelphia, Pa.

PITTSBURGH SECTION

Monday, March 14, 1955 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Patents and the Engineer," by Harold S. Silver, General Patent Attorney, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Alumni Room, University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, March 30, 1955 — Dinner 6:30 P.M., Meeting 7:30 P.M.

"Automation of Processing Equipment for Steel and Brass Mills," by H. W. Lynn, Sales Manager, Wean Engineering Co., Inc., Warren, Ohio.

"Automatic Cold Drying" — Film.

Skaggs Restaurant, Alton, Illinois

SAN FRANCISCO SECTION

No meeting scheduled.

YOUNGSTOWN SECTION

Monday, March 28, 1955 — Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Welded Structures as Applied to Cranes and Steel Mill Equipment," by I. W. Evans, Chief Welding Engineer, Morgan Engineering Co., Alliance, Ohio.

Mahoning Country Club, Girard, Ohio.

J&L Starts Hot Extrusion Operation at Pittsburgh Works

▲ PRODUCTION of "custom-made" extruded carbon steel sections by the Ugine -Sejourned Process has begun at Jones & Laughlin Steel Corp.'s new $1,260,000 hot extrusion plant. The plant, adjacent to the Hazelwood cold finishing department, Pittsburgh Works, is installed in a new building 60 ft wide and 260 ft long.

Initially the plant will produce extrusions in solid sections. These sections will range in weight from 1/3 to 12 lb per lineal ft, and up to 24 ft in length. Main production of the plant will consist of complex sections that cannot be rolled, with small tonnages of rollable special sections for which rolling is uneconomical. Because the extruded sections can be produced economically in small quantities, they will be "custom-made" for each order.

These sections should find a ready use in manufacture of parts for business machines, electrical equipment, agricultural machinery, automotive products, machine tools, air-conditioning machinery, and ordnance material. Many parts now being made from castings, forgings, or machined to intricate cross section from solid bar stock, can be replaced at substantial savings by hot extruded cold drawn sections.

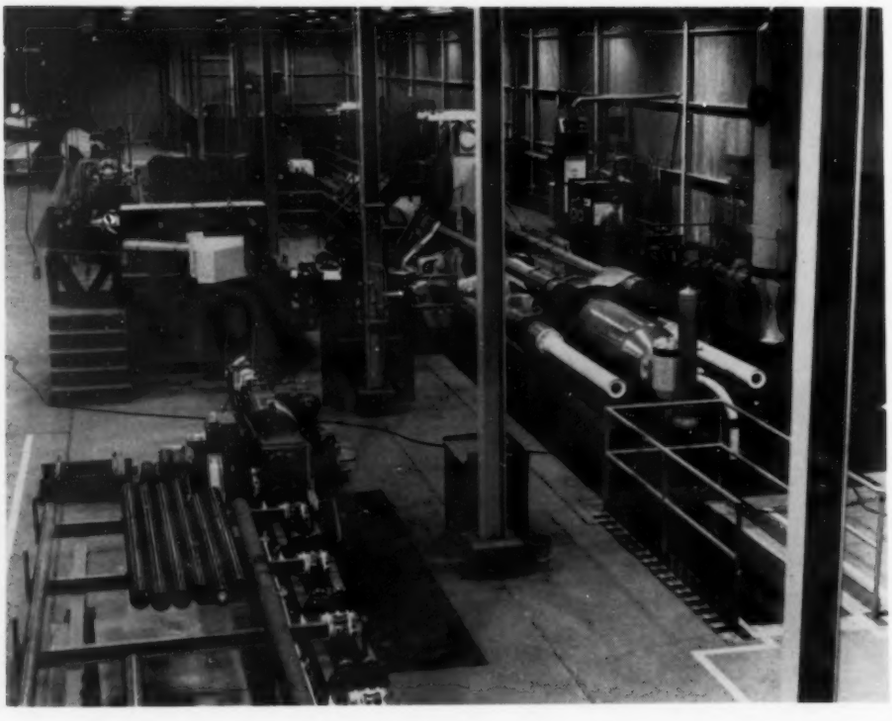

Figure 1 — Over-all view of the new hot extrusion plant shows in foreground the automatic billet cut-off machine. Back of it is the induction heating furnace. The hydraulic extrusion press is located at the right. Runout table and cooling beds can be seen in the rear center. And to the rear left center is the stretcher-detwister. The equipment in the far upper left is the shot cleaning machine.

Figure 2 — Close-up of 1000-ton hot extrusion press shows hot billet in the press manipulator being pushed toward the die container.

Close tolerance of the sections allows the fabricator to use most of the extruded sections practically as they are. Generally, all the fabricator has to do is cut the sections to required lengths, saving machining time, machine tools, cutter cost and maintenance, and milling and profiling.

The extrusion press was designed to J&L specifications and built by Loewy-Hydropress, Inc., N. Y. It is hydraulic-powered, with a horizontal stroke, and can operate at pressures up to 1000 tons.

The production sequence is all done automatically. Hot-rolled rounds are cut to billets of pre-determined length by an automatic cut-off machine. Size

Four Open Hearth Furnaces designed by Rust for Lone Star Steel Company's modern steel mill at Lone Star, Texas

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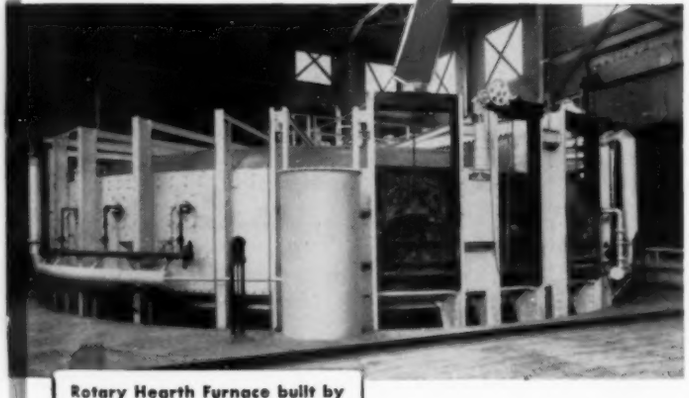

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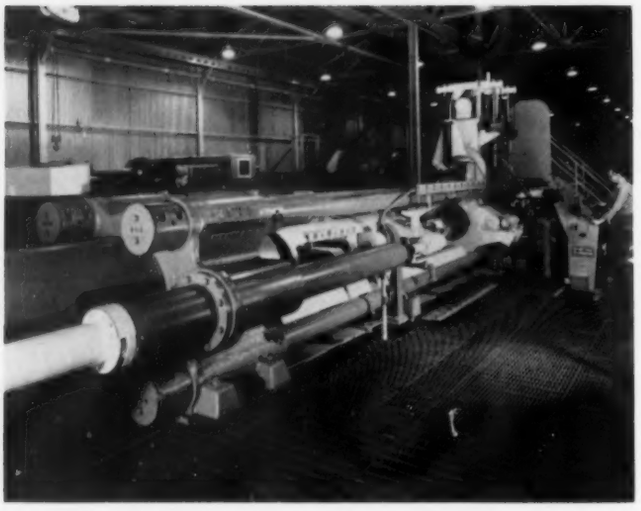


Figure 3 — The 1000-ton horizontal extrusion hydraulic press squeezes out complex sections of low carbon steel bars.

Figure 4 — From the extrusion press, the finished extrusions roll out onto a cooling table and are straightened in this "stretcher-detwister."

of the billets varies from 4 in. in diam and 6 in. long to 5 in. in diam by 20 in. long, with a maximum weight of 110 lb.

The billets are heated in a Magnethermic induction heating unit, which is provided with an inert gas atmosphere. The billet passes through a pre-heat coil, then through a high-heat coil, where it is heated to 2300 F. The two heating steps take only a minute.

When they emerge from the heating unit, the billets roll through powdered glass, which serves as the die lubricant. An automatic loader picks up the billets and transfers them to the loading end of the extrusion press.

In the extruding operation, the hydraulic ram positions the hot billet, then pushes it through the die. The extruded bar is conveyed automatically to a cooling bed. After cooling, the bar is stretcher-straightened and de-twisted. An American Wheelabrator shot-blasting machine cleans glass and scale from the bar.

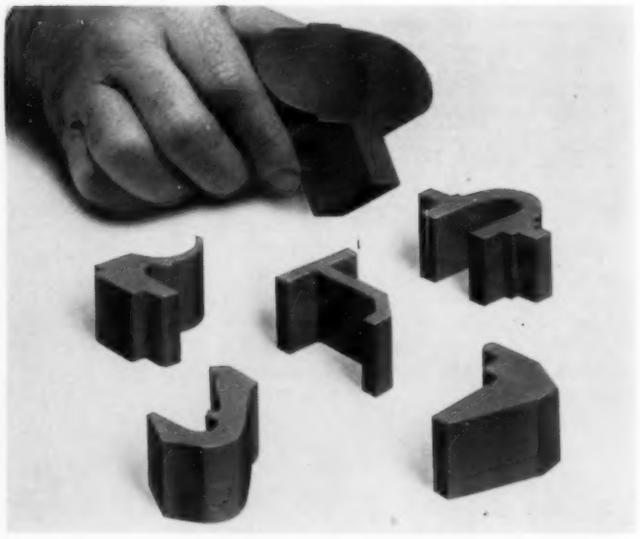
To give close dimensional accuracy and fine finish to the bars, they are cold-drawn at J&L cold finishing facilities. J&L makes its own dies for the extrusion press. Tungsten-chrome steel is used. After each hot extrusion, residual glass lubricant is shot-blasted from die.

Production of extrusions at the new plant is licensed by the group of French manufacturers who developed the Ugine-Sejournet hot extrusion process. The licensing company is Comptoir Industriel & Profilage de Metaux. It was they who discovered that glass would provide the lubrication necessary to prevent rapid wear and seizing of dies in the hot extrusion process. This discovery enabled them, in 1940, after many years of research, to extrude steel bars, shapes, and tubes. They found that the glass, besides being an efficient lubricant, also serves as an insulator which protects the die from contact with the hot billet.

Production and marketing of the hot extrusions are under the management of J&L's cold drawn bar department.

Figure 5 — Induction heating facilities at the hot extrusion plant heat 50-lb solid steel billets from room temperature to about 2300 F in one minute. The hot billet shown on the table, right center, is rolling from the furnace at the left toward the extrusion press at the right. Powdered glass on the roll-out table sticks to the billet and acts as a lubricant in the extruding operations.

Figure 6 — A few of the wide variety of shapes that can be extruded at J&L's new hot extrusion plant at Pittsburgh. Initial production will be in solid extrusions of complex and special shapes that cannot be rolled, and rollable sections in small uneconomical rolling quantities.



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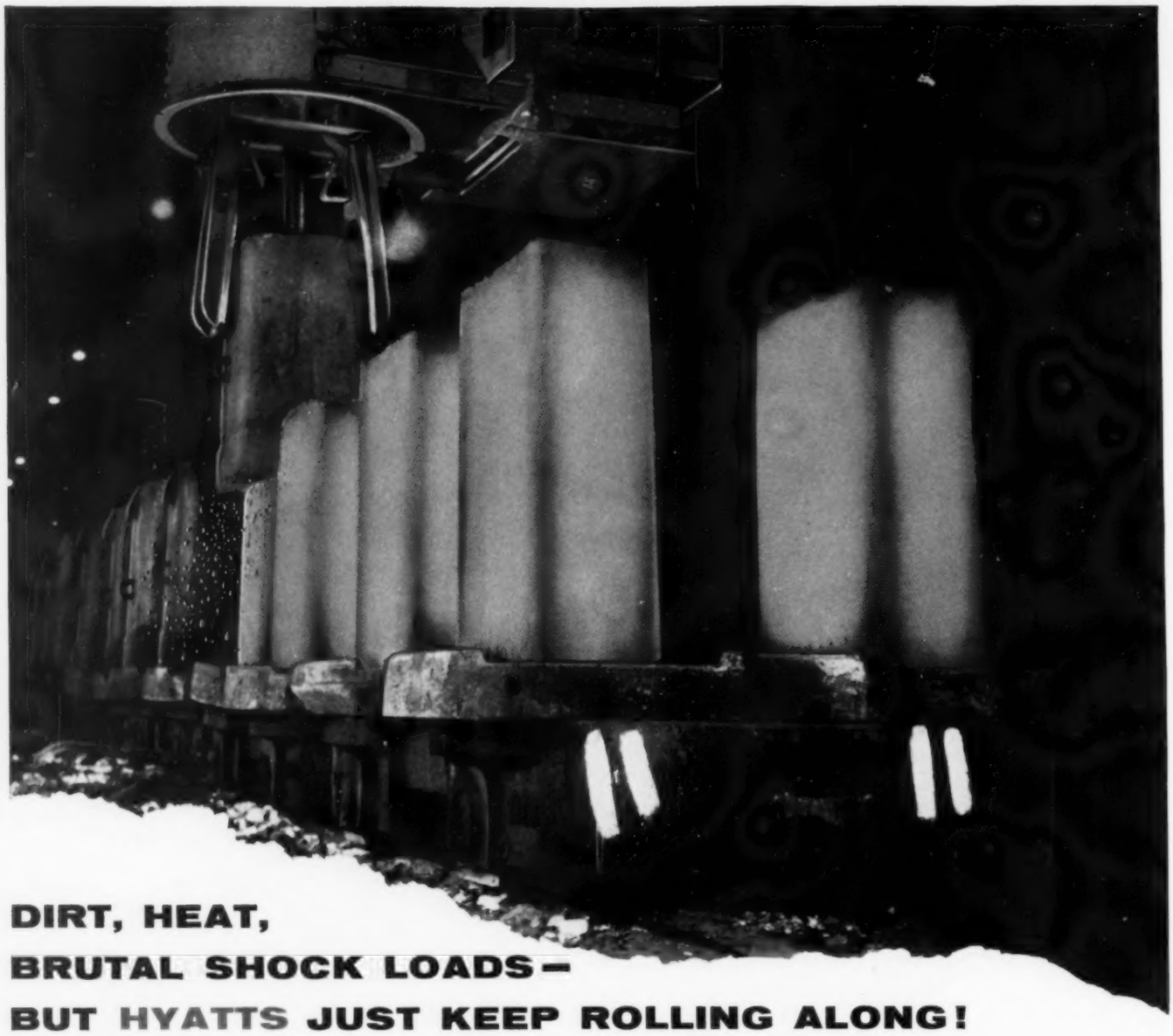
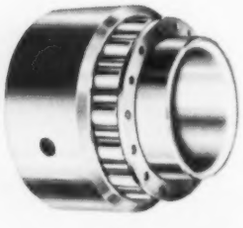


DIRT, HEAT, BRUTAL SHOCK LOADS— BUT HYATTS JUST KEEP ROLLING ALONG!



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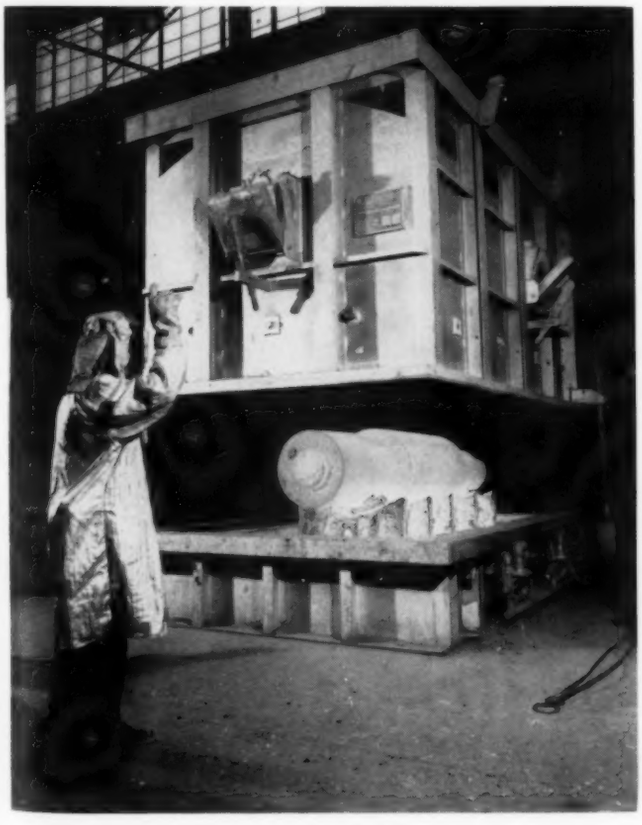
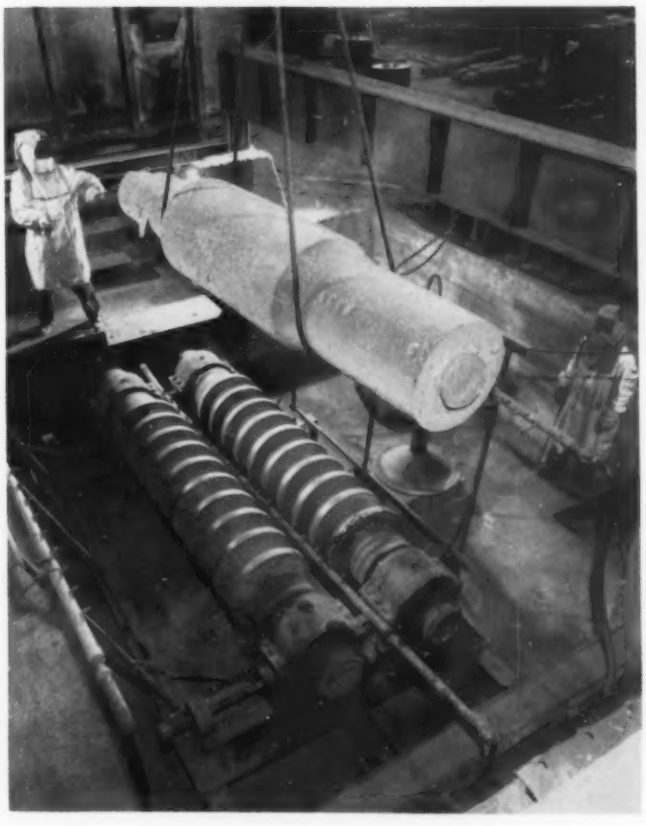
▲SINCE a complex, modern strip mill including all its auxiliaries represents a vast outlay of money, it must produce or the downtime charges will run into astronomical amounts. An average cost of $1000 per hour for downtime is not unreasonable. When rolls are pulled for redressing, or when any single roll fails, the loss-time clock begins ticking.

Basically, there are six major factors which determine the life which can be expected from any roll. They are metallic composition, molding practice, melting practice, feed of metal to the mold, heat treatment, and conditions under which the roll will be used.

When a roll order is received at Blaw-Knox, the first step is to call a meeting where the desired characteristics of the end product are outlined and discussed. Foundrymen, salesmen, metallurgists, and management detail the techniques of production.

Figure 1 (left) — By heat treating only one roll at a time, Blaw-Knox is able to produce a roll which is tailor made to the customer's requirements. This early stage stand hot strip mill steel work roll has been in the furnace for several days. The automatic furnace controls have recorded a time and temperature change chart which can be checked against original specifications. Figure 2 (right) — Clad in asbestos suits so they can handle this white hot roll, workmen direct lowering it to a spinner where it will be cooled. After heat treating, the roll will be machined to proper dimensions and finish, then shipped to the customer.





While certain general patterns will apply, each roll is, nevertheless, tailor-made. For a strip mill work roll, the basic requirements are normally surface hardness and a penetration of that hardness, so that the roll can stand many redressings. The roll must also have ductility and resistance to spalling. Almost conversely, a blooming mill roll must have built-in strength to withstand shock, resistance to fire cracking and wear. Here are two opposite problems in roll-making.

While heat treating actually begins with the molding techniques, since chillers in the mold affect the rate of cooling of the casting, thereby affecting the hardness, the real heat treating especially in steel rolls begins after the rolls are solidified and are shaken out of the mold.

Since 1950, Blaw-Knox has been heat treating these large masses with all the skill and the newest equipment it can bring to bear on the problem of producing better rolls. That year the company installed 12 new cycle control furnaces, replacing the open pit-type furnaces which they had been using.

According to Dr. F. H. Allison Jr., vice president of Blaw-Knox in charge of rolls sales and metallurgy, the new furnaces have paid off in two ways:

1. "In the old furnaces from 300 to 400 tons of rolls would be put into the furnace at one time. While this seems like poor practice, and is, it is still not uncommon in the industry. Each roll in the pile was given the amount of heat treatment necessary for the largest roll. In the new furnaces it is possible to heat treat only one roll at a time, and this roll can be given the rate and soaking time best suited for its individual dimensions.

2. "The new furnaces can be cycle regulated, which permits the heat treatment supervisor to set up a series of temperature changes. A charting unit for each furnace also makes a record of time and temperature changes, which can be checked against original specifications."

In these furnaces, each roll is given an individualized treatment, tailor made for the job it is to perform. Treatments include annealing, normalizing, quenching and tempering, and often combination practices.

In the annealing process, the as-cast structure of the roll is modified from a fairly coarse to a finer grain, and since the rate of cooling is slow, the process will provide minimum hardness.

Normalizing, a faster rate of cool for a roll, increases the hardness, tensile strength and yield strength with only slight modification of the roll's ductility as compared with the annealed state. This process is normally followed by tempering which involves reheating. This system is used especially in treating larger rolls.

In single, double or triple annealing, the temperatures range from intermediate to very high. The time may vary depending upon roll size, from one week to 10 days for single annealing and from 10 to 20 days for special hardness treatments.

Quenching and tempering treatments are not infrequently used. Like the many factors involved in molding, casting, and feed of metal to the mold, the quench may also vary, ranging from quick to slow. Degrees of quenching include air blast, water spray, and full water. The faster the cooling, the harder the roll. Techniques have also been developed for differential cooling so that a hard body may be combined with ductile and shock resisting necks.

The final variant is mill practice. Control over this is experience in understanding the usage to which the customer may subject the roll.

SHOP DESIGN AIDS BATTERY MAINTENANCE

▲ THE new battery charging room (50 x 100 ft) of the cold-rolled sheet mill of Pittsburgh Steel Co. of Allenport, Pa., was planned to make it easy to charge and maintain the batteries that power their large ram (Figure 1) and fork-lift trucks.

First of all, all batteries are charged in a central station under proper supervision. The central station is large with ample room to work around the batteries and also allow for future expansion. The charging area is fully enclosed with a wire fence to keep out unauthorized personnel. Maintenance and repairs on the trucks are also done in the enclosed space but in a section set apart from charging.

The control panels (Figure 2) are placed against one side of the charging area with the charging leads brought through conduits under the floor, out of the way, to the charging racks.

The battery charging racks are made of steel channels set off the floor (Figure 3) to bring the batteries to a handy height for maintenance as well as to provide air circulation to keep battery temperature down.

According to future plans, air will be forced under the batteries by blowers.

The racks are designed to protect

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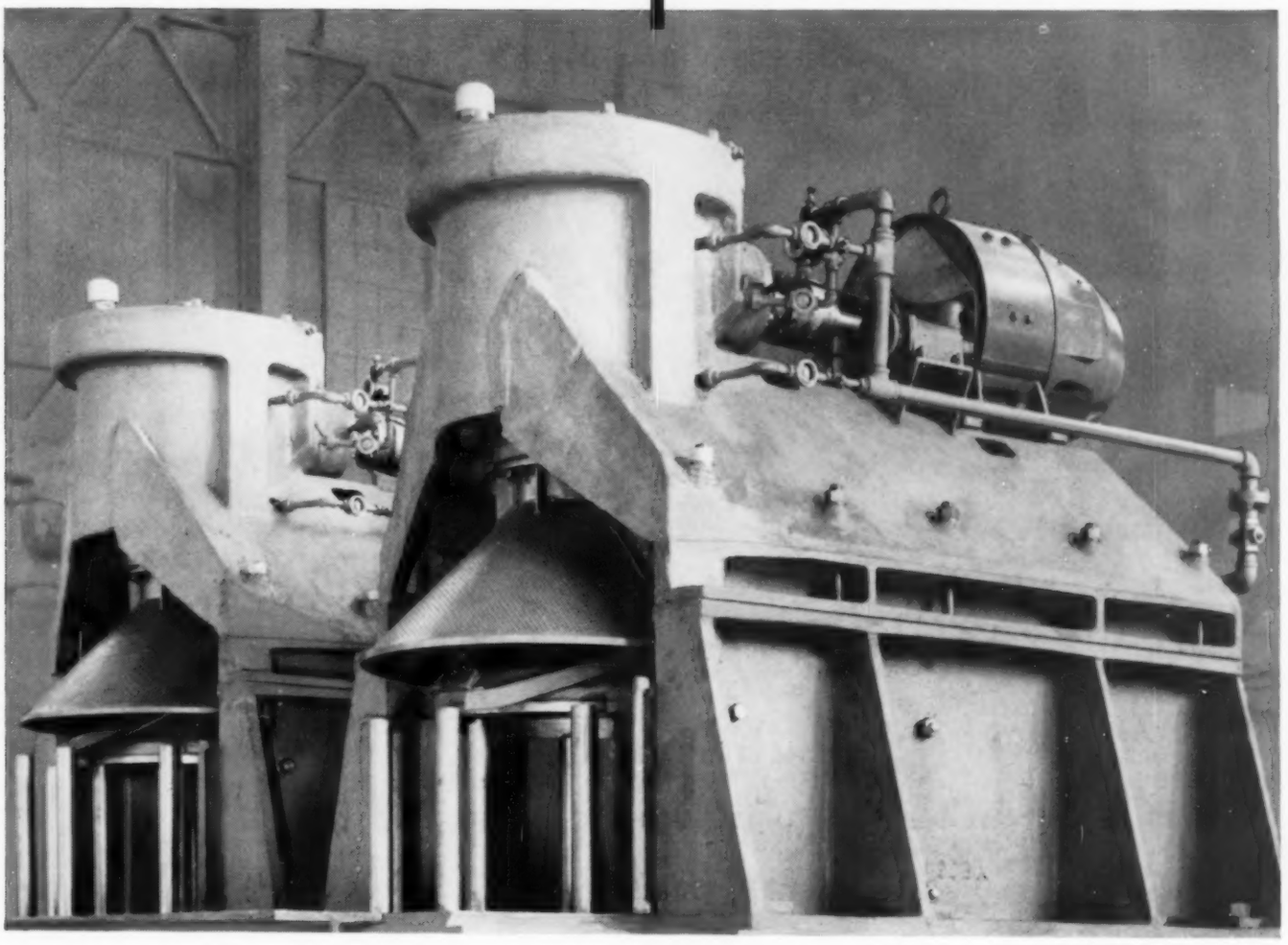

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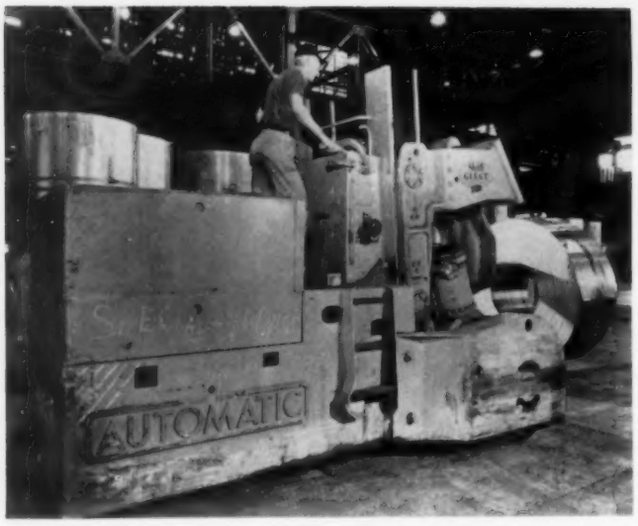

Figure 1 (left) — Two 1000 amp-hr batteries power this ram-truck. Coil on truck in photo weighs 16,000 lb. Trucks can handle two coils at once. Figure 2 (right) — Control panels for charging 18-1000 amp-hr and 12-600 amp-hr batteries are set against side of battery room out of the way and yet accessible. Leads from panels are placed in conduits under floor and brought up to permanent, fixed plugs for each battery.

batteries against accidental bumping and damage from the trucks by means of horizontal channels on all sides of the racks.

An ingenious safety idea may be seen in Figure 3. The locking half of a standard plug without the terminals is placed over the receptacle (which brings power from the control panel) when a battery is not plugged in for charging. This prevents dirt, tools or fingers from entering the plug. The hole for the charging lead is blocked off by insulating material.

A large sink (Figure 4) with substantial concrete sides and adequate drainage through a grill indicates the importance attached to cleanliness by the Pittsburgh Steel Co. Batteries are washed frequently and regularly with water and dried with air.

Distilled water produced by a still in the battery room and contained in a portable raised tank (Figure 5), is used to refill cells to replace electrolyte lost through evaporation.

All of the batteries are large. One section of racks is designed for 1000 amp-hr batteries of which there are 16 and the other for 600 amp-hr units of which there are 12 at present. There are spaces in the rack for all the batteries now in use although normally one-half are in service in the trucks. This provides room to give all batteries an equalizing charge regularly.

There are at least two batteries per truck. Some of the large ram-trucks are designed for two 1000 amp-hr batteries per shift and there are four batteries for each of these trucks to permit three-shift operation.

Battery lifting and handling is done by a large bridge crane that serves the entire area. This is part of the handling equipment already in the building in which the battery room is located. The crane has been equipped with pendant controls operated from the floor by the battery room personnel. Limit switches prevent its use anywhere but in the battery charging room.

Records are kept on each battery on forms recommended by Gould engineers.

Figure 3 — Battery racks are of substantial steel channel construction, and are placed at correct height for ease in conducting maintenance work and to permit air circulation around batteries. Horizontal channels protect batteries against accidental damage from trucks. Note that receptacle is fixed to rack and that it is covered with a dummy locking half when a battery is not being charged to keep out dirt, tools or fingers.

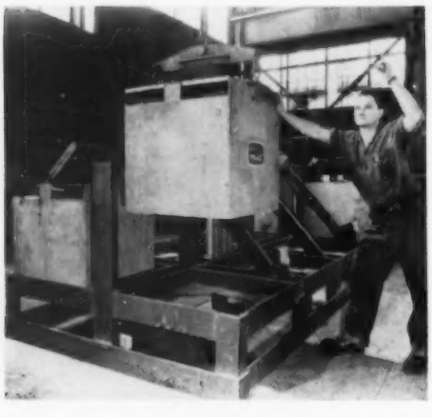

Figure 4 — Batteries are cleaned regularly in this washing pit.

Figure 5 — Distilled water from battery room still is brought to charging racks in this 30-gal portable tank.

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NEWPORT STEEL

Puts New Cold Mill in Operation

▲ INDUSTRY'S heavy demand for cold rolled steel was provided a fresh source of supply on January 26 with the formal opening of Newport Steel Corp.'s new reversing cold mill. The event marked the addition of another end product to Newport's growing list of flat rolled sheet finishes.

Newport Steel, whose history dates back to 1885, is one of the few mills in the United States where strip is hot rolled directly from ingot into finished coil in one straight line operation. With the new unit, Newport can now convert these hot rolled coils into cold rolled sheets to the exact gage and finish specified by the automobile industry, appliance manufacturers and other users of steel. The mill has been test run since early December.

The unit is a major item in a $9,000,000 expansion and modernization program that has been underway at Newport Steel. It will operate at strip speeds up to 1,700 fpm, reducing hot rolled pickled coils to desired gage in coil widths for shearing into flat sheets up to 48 in. wide. Work rolls are 18-in. diam x 56-in. long. backup rolls are 49-in. diam. The 4-high stand is driven by a 3000-hp motor, and each reel is powered by a 1000-hp motor.

In addition to the cold rolling mill, other improvements completed and put into operation at Newport in the past year have included a new reversing hot strip mill, culvert coating equipment, facilities for production of arch culvert pipe, new conductor pipe and gutter machines, and extensions to the electric weld line pipe mill.

At Newport, ingots first go through a slabbing mill, where they are reduced into flat plate $\frac{5}{8}$-in. thick and approximately 135 ft long. The plate then goes to the new hot reversing strip mill, installed last summer, where it is rolled into a coil from $\frac{1}{4}$ to $\frac{1}{16}$-in. thick, up to 48 in. wide and approximately 1,350 ft long.

From the hot mill, the coils go to the continuous pickling line for removal of scale. As each is decoiled through a scale breaking unit, it is stitched to the preceding coil and is pulled through successive baths of sulphuric acid and hot water. After passing through a trimming unit that produces a machined edge by shearing approximately a half-inch from either side, of the strip, the steel is recoiled on a tension reel.

From the pickling line, the coils go to the new 4-high reversing cold mill where the strip is reduced to specified gage and finish.

The mill is capable of handling coils weighing up to 40,000 lb, with an inside diameter of 24-in. and an outside diameter of 65-in.

After being cold rolled, the coils go to a continuous flying shear where the steel is uncoiled, flattened and cut to proper lengths and widths according to ordered sheet specifications. The sheets are then annealed in gas-fired, controlled atmosphere furnaces, are temper passed, and—after thorough final inspection for surface finish, gage and size—are packaged for shipment.

Figure 1 — New reversing cold mill at Newport Steel Corp., a 4-high unit, will roll at strip speeds up to 1700 fpm.

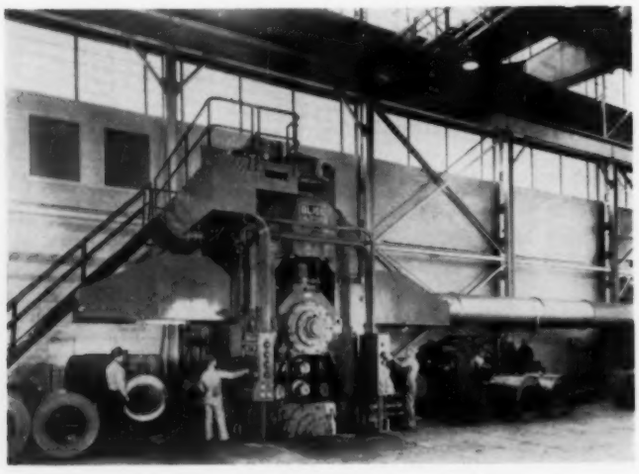

Figure 2 — Reversing mill is powered by a 3000-hp motor; and each tension reel has a 1000-hp motor. The main motor-generator set is equipped with a 4500-hp motor.

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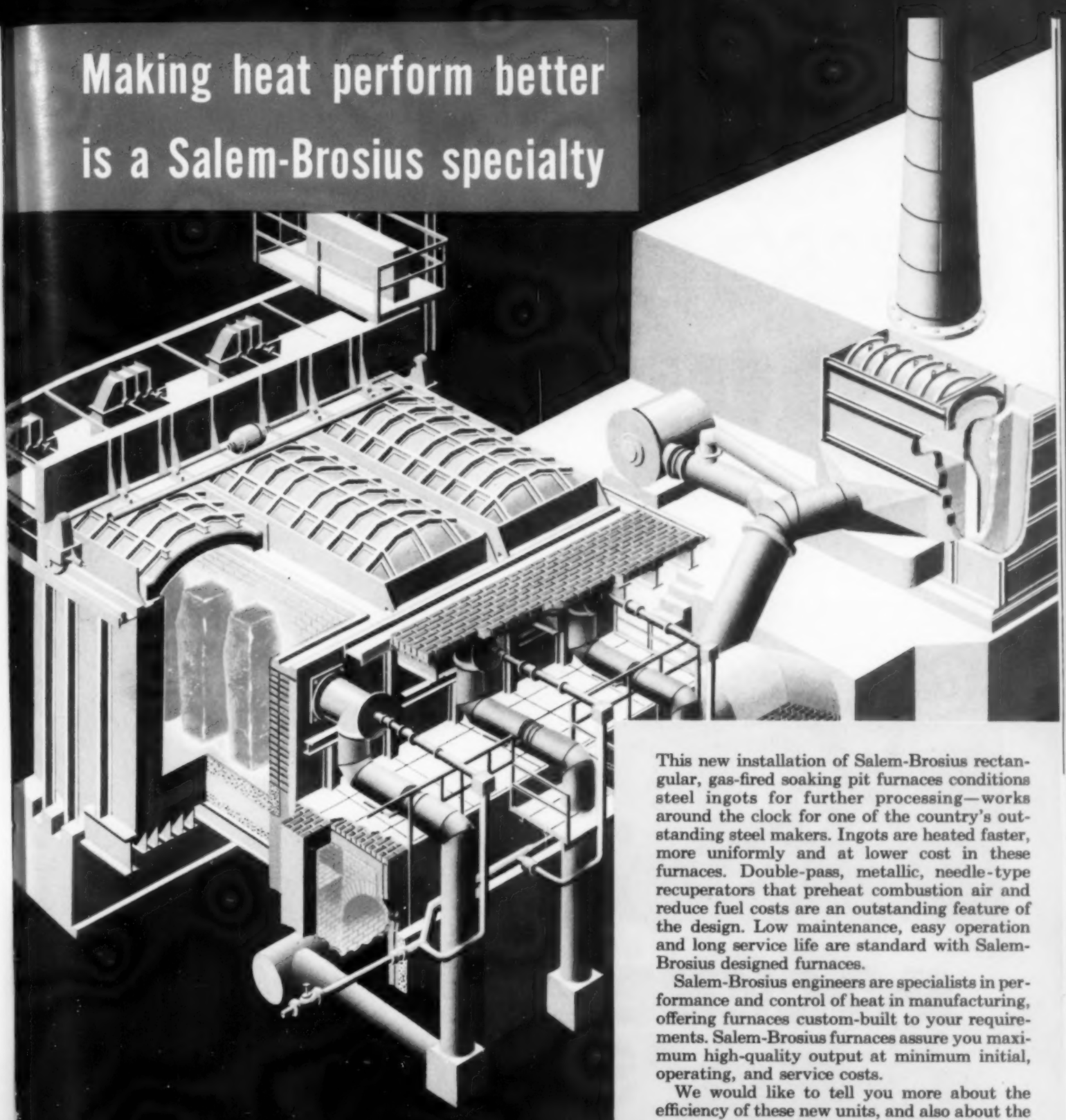

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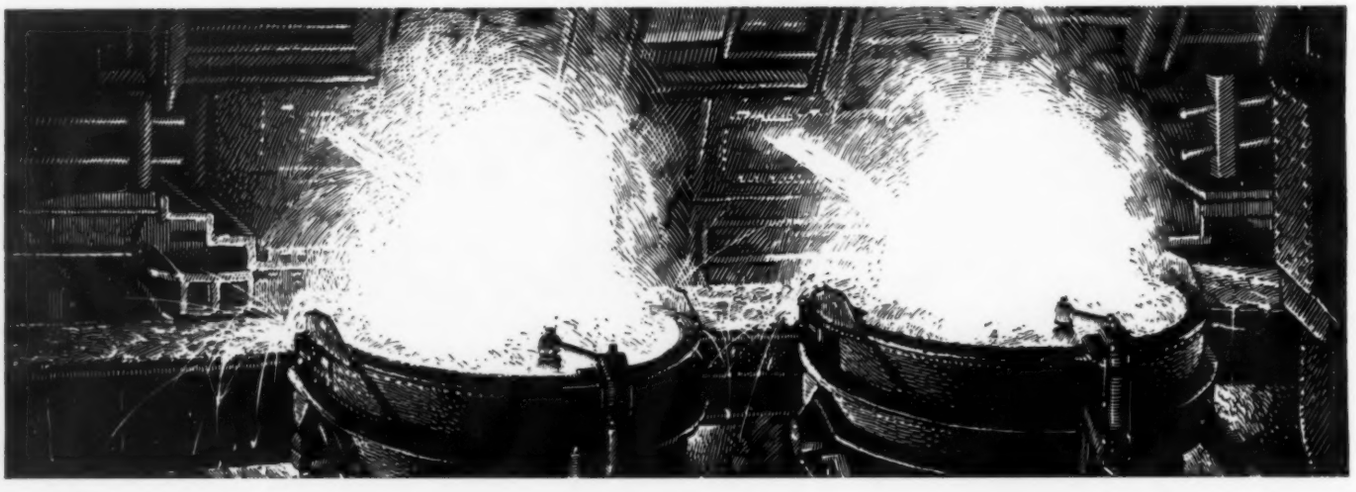

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PLASTIC ROLLS help in Producing Tinplate

▲ CONTINUOUS production lines for finishing strip material employ great numbers of rolls to guide and control the movement of the material through the unit. These rolls are subjected to a variety of operating conditions, depending on the process, such as moisture, acids, abrasion, temperature. Further, the rolls must differ in hardness and in some cases must act as electrical insulators.

Such severe requirements, plus the higher speeds at which modern finishing lines operate, result in short roll life—in many cases, only a week.

To overcome this difficulty, Steel Plant Equipment Corp., in conjunction with Synthane Corp., has developed rolls coated with thermosetting laminated plastics. By using different fabrics and bonding with different resins and plastics, rolls of various characteristics are made to meet almost any operating conditions.

The steel rolls are machined so as to leave a slightly roughened surface. The rolls are then heated to 250 F, placed on a winding machine and, with the roll itself serving as a mandrel, wrapped with the specially impregnated fabric to slightly more than the required thickness.

After wrapping, the laminate-covered rolls are oven-cured at temperatures depending on the type of impregnation (about 300 F) to insure thorough polymerization. Roll ends are then trimmed flush and the roll body is turned down to the desired diameter in a lathe.

Because of the density of the laminate covering, foreign particles do not imbed themselves and mark the strip, as sometimes happens with rubber-covered rolls. This surface toughness also eliminates patterns on the strip which sometimes results from abraded particles of rubber adhering to the strip and preventing deposition of tin. Since the laminates are non-magnetic and anti-static, they do not pick up metallic chips which might scratch the product surface.

The excellent wear resistance of the new rolls reduces the principal cause of excessive vibration and chatter, which are highly undesirable in high speed tinning.

The character of the new coatings also make them excellent in handling aluminum, copper and other softer metals, where a steel roll might damage the material.

Thus far, in addition to general purpose rolls, special rolls have been developed for acid resistance and for the frictional characteristics usually desired in pinch rolls. A roll with marked temperature resisting qualities is under development.

The synthetic-covered rolls are in use in electro-tinning lines, pickling and scrubbing lines, cleaning lines, galvanizing lines, etc., in many of the largest strip mills, and have achieved operating life of three to five times that of rubber-coated rolls.

Longer life, of course, means reduced maintenance cost and less down-time, which in turn means increased production.

Figure 1 — Fabrics for laminating rolls are wrapped on the roll under tension and temperature to give a dense cover.

Figure 2 — The finished coatings may be turned to size on a lathe.

Innovations Mark Production of Electric Weld Tubing

▲ A broadening of customer requirements for special types of tubing as well as for different types of paint and plastic finishes on that tubing is turning the Electricweld Tube Division of Jones & Laughlin Steel Corp. into one of the most specialized divisions of the company.

The Electricweld Tube Division uses flat rolled coiled strip steel from 0.022 to 0.154-in. thick, weighing from 3,000 to 10,000 lb per coil, and varying from 24 to 33½-in. in width. Shipments of the strip are made by truck or railroad to Oil City from the Pittsburgh and Cleveland plants. Incoming coil strip shows a wide variety of physical properties and chemical content, depending upon the final applications scheduled for the tubing.

The first step in the production of tubing is the slitting of the strip steel coils to size. This operation is performed by standard slitting machines, equipped with disc knives. Re-reeling of the new, thinner coils follows before the steel is taken to the continuous welding mills.

The "by the mile" concept of tube fabrication at this plant begins during continuous welding, at which time as many as eight of the new coils are end-welded together to form single reels of 6,000 ft or more. The strip is then progressively roll-formed into tubing on any one of six electricweld mills, which produce a product ranging in size from ⅜ to 4-in. outside diameter, inwall gages from 22 down to 9. In the welding section of the mill, the edges of the strip steel are electric-resistance welded. The edges of the cold formed unwelded tubing pass longitudinally between two rotating electrodes or copper disks.

After welding, the tubing goes into the sizing section of the mill, where it is cooled with an emulsion consisting of 12 to 14 per cent soluble oil in water, and reduced slightly to exact size.

The speed with which steel can be moved through the welder at Oil City varies with the gage and grade of the steel itself, and to the ultimate application. Lighter gages go faster than the heavier gages, with average moving between 80 and 100 fpm.

The welding completed, a cut-off machine connected directly to the mill cuts the tubing to the required length. Three different types of cut-off units may be used:

1. The punch cut, with a blade like a dagger, which stabs down through the tubing.
2. A traveling disc-type cutter which slices down through the tube wall.

Figure 1 — A large recoil at the entrance of the welding mill at Jones and Laughlin Steel Corp.'s Electricweld Tube Div., Oil City, Pa. This coil contains 6000 to 8000 ft of slit strip steel which will be fed into the forming rolls.

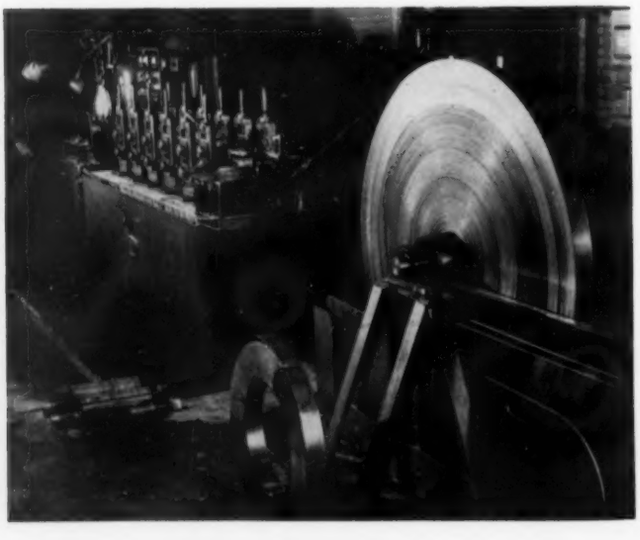

Figure 2 — Close-up of the welding electrodes shows the tubing under the electrodes and the welding mill pressure rolls holding it in position while it is being welded.

Midwestern Steel Operator

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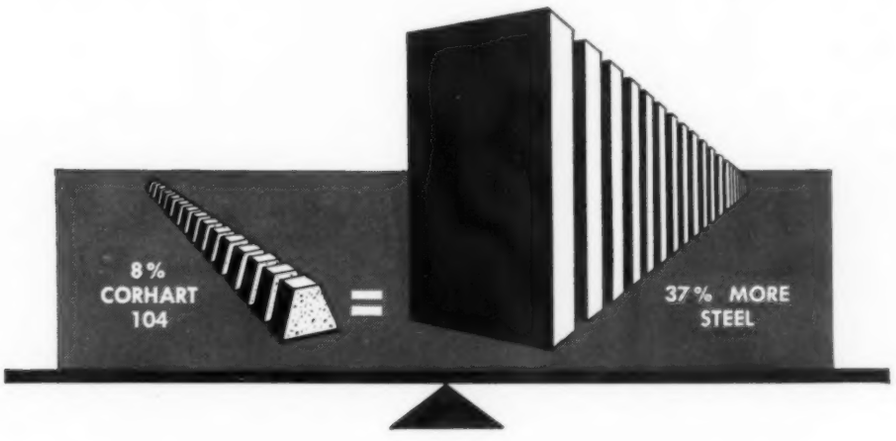

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Figure 3 — A rotary tube straightener keeps out-of-straightness variation well within the 0.010 per ft of allowable straightness variation.

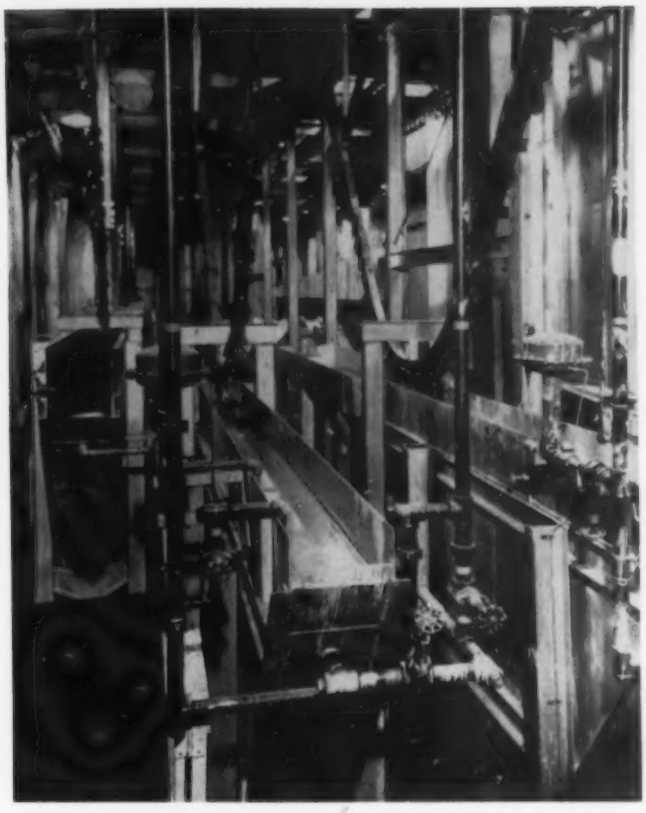

Figure 4 — After the tubing comes out of the dip tanks, it goes into a gas-fired oven which bakes on the paint coating.

3. A traveling lathe — a head equipped with a parting tool which revolves around the tube.

Straightening of tubing is performed by adjustable roll straighteners, prior to shipment or further fabrication. In addition, Perma-Tube formed for television masts goes to special equipment, where ends of the tubing are swaged and expanded to form a fitted joint, making possible the telescoping of one piece of tubing into another.

The widening market for various shapes and sizes of tubing is closely reflected in the painting and finishing lines of the Electricweld Tube Division. In this line, equipment has been installed or engineered to provide necessary versatility in handling the various sizes of tubing while guaranteeing coating weights, appearance, and thickness of the coating. Key link in this entire operation is an overhead conveyor system, which stores and transports the tubing on hooks into and out of the line of dip tanks.

Perma-Tube for television masts represents a substantial portion of the Oil City plant's out-put, and the painting and finishing line is geared for special handling of this tubing to apply corrosion-proof coating inside and out. In this operation, tubing receives its metal pre-treatment—a combination metal treatment and metal primer, vinsynite — followed by a finish coating of a tightly adhesive aluminum-pigmented vinyl resin base.

To expedite movement of tubing on the overhead conveyor system, J&L engineers designed a procedure that makes possible a hookup of tubing up to 10 ft in length as fast as the following production sequence requires.

The tubing first passes through a series of hot alkaline cleaning and rinse tanks. After moving through the final tank, the tubing is rinsed in clear water, kept clean through the constant addition of fresh make-up water. This water is heated to hasten the drying of the tubing after painting.

Strength of the solution in the cleaning tank and temperature of the cleaning water are both electronically controlled.

The dried tubing then passes through two successive installations, each of which comprises a coating tank and a gas-fired oven. The first oven bakes on the initial coating a metal pre-treatment vinsynite applied to the tubing in the first coating tank. The tubing then takes another dip in a second tank to get the outer protective coat. This is followed by baking in another oven whose temperature is considerably higher than that of the first.

Tubing then cools at room temperature as it circulates on the line for approximately eleven minutes. An unloading mechanism, similar to that which pulled tubing on to the conveyor system, removes the finished, coated tubing for final inspection and preparation for shipment.

All heating units and all tanks on the cleaning and paint line are automatically controlled by electronic devices. To insure good finish, paint is mixed before it enters the tanks, and paint viscosity is checked every two hours.

Since interchangeability is a major design feature, the tubing is closely examined for straightness. The shoulder of the joint also is inspected, and every third piece is checked with a plug gage for dimensional accuracy. After painting, samples of the tubing are subjected to destructive tests, salt spray for corrosion resistance and weld tests.

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- Modern Honeywell instrumentation improves product quality. Precision measurement and control remove any chance of error or guesswork in critical processes.
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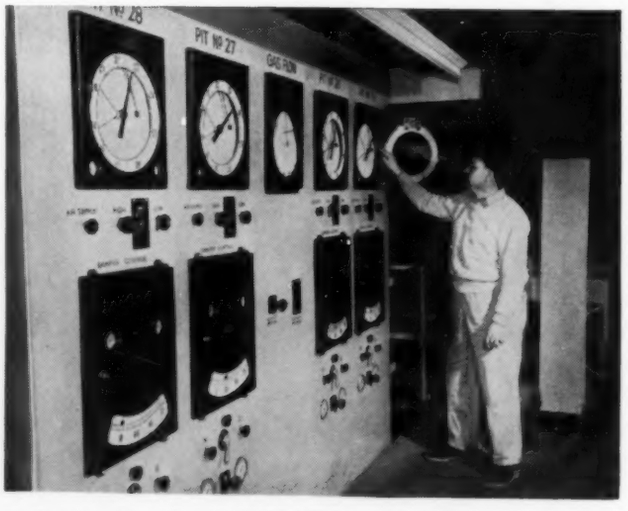
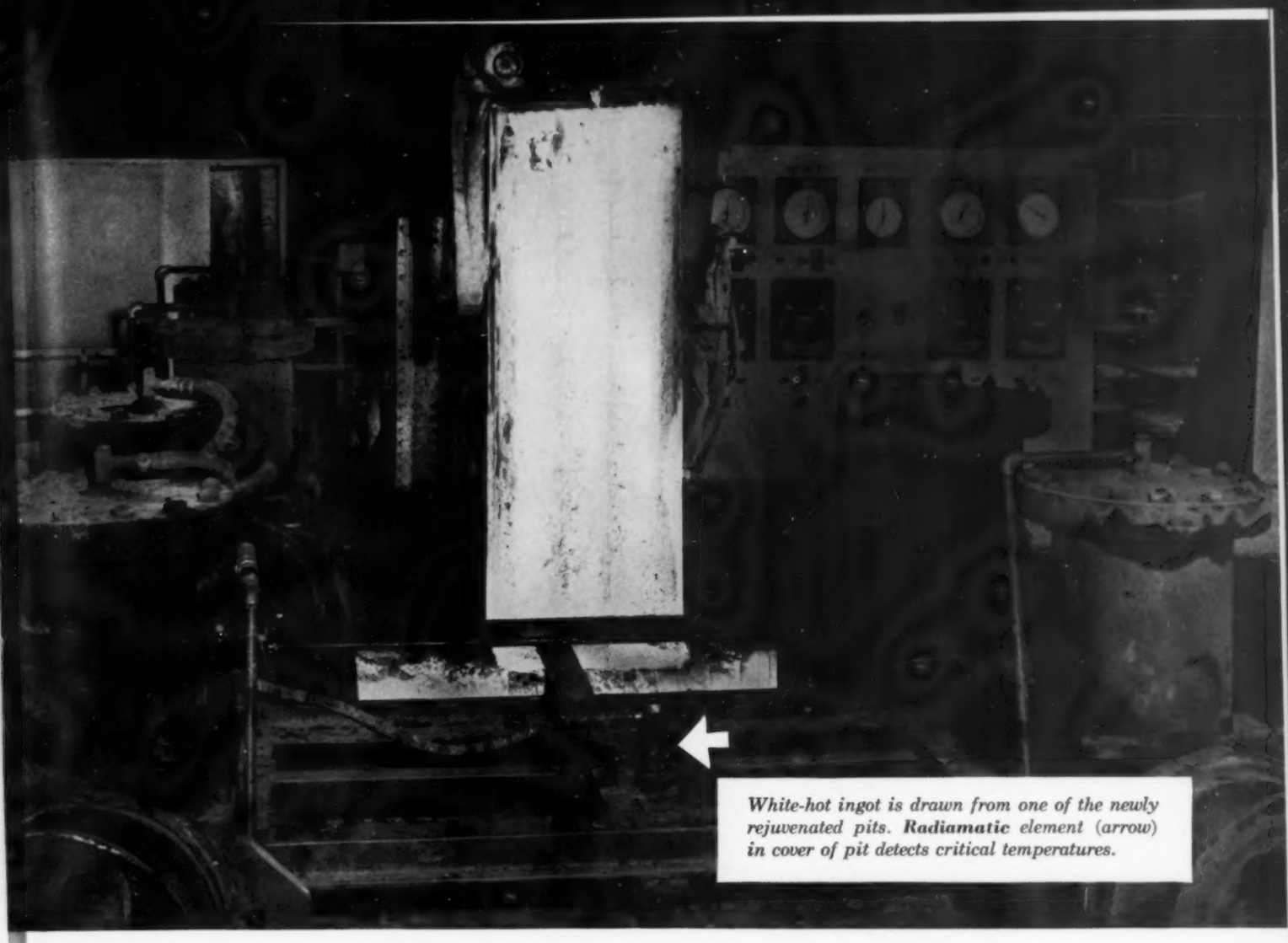
C F & I reaps big savings from pit modernization



A focal point of modernization is this Brown instrument control panel for four regenerative soaking pits. Savings accomplished on this installation have led CF&I to decide on similar modernization for all pits in the mill.



White-hot ingot is drawn from one of the newly rejuvenated pits. ***Radiamatic*** *element (arrow) in cover of pit detects critical temperatures.*

using Brown® instruments

FIFTY-YEAR-OLD soaking pits at Colorado Fuel & Iron Corp. have been brought back to a new peak of efficiency, by means of a thorough modernization program which makes full use of up-to-date Brown instrumentation.

Four of the 28 pits for the 40-inch mill were tackled first, to see how the program would work out. Height and width were modified to provide better combustion, and new covers installed to give better seals. Most significant improvement, however, was the installation of complete, centralized instrumentation . . . consisting of *Radiamatic*® radiation detectors for pit temperatures, *ElectroniK* controllers for regulating fuel input, an automatic reversal system, Brown Furnace Pressure Controllers actuating new damper systems, and Brown Flow Meter for totalizing fuel consumption.

After almost a year's operation, the dollars-and-cents results have exceeded all expectations.

- Yield has increased by $14,000 per year, due largely to improved uniformity of heating and better surface conditions.
- Crane time has dropped 15 to 25 per cent because ingots no longer need to be charged bottom side up for correct heating.
- Fuel rate has dropped about 25 per cent as a result of improved heating efficiency.
- Pit life increase is estimated at 50 per cent . . . refractory savings amount to 6 cents per ton.
- Daily bottom making has been slashed from 1½ hours to 25 minutes for the row.

Your nearby Honeywell sales engineer will be glad to discuss how modern instrumentation can become an important . . . and fruitful . . . part of your own modernization program. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for the new booklet "Modernization", and for Catalog 1531, "*ElectroniK* Controllers."**

MINNEAPOLIS **Honeywell**

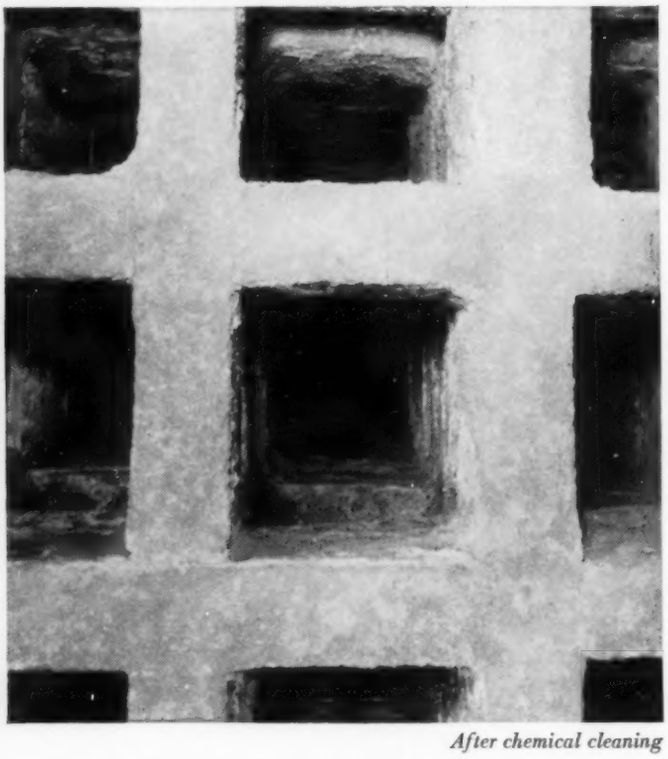
BROWN INSTRUMENTS

First in Controls

FOUR OPEN HEARTH CHECKER CHAMBERS CLEANED IN 10½ HOURS

Expensive rebricking job avoided; deposits removed from checkerworks by DOWELL engineers using a high-pressure solvent jet

Before chemical cleaning



After chemical cleaning

Recently, Dowell was called to clean four badly fouled checkerwork chambers of an open hearth furnace. A high-pressure solvent jet, designed by Dowell to combine chemical and hydraulic action, made it possible to complete the job in only 10½ hours!

Inspection after cleaning showed the checkerworks to be free of deposits. This cleaning by Dowell Service avoided an expensive rebricking of the checker chambers which would have required a maintenance shut-down of four or five weeks.

This was the fourth time these checkerwork chambers had been cleaned by Dowell—and the fourth time that the operator had been well pleased with the results.

The high-pressure jet is used by Dowell engineers to spray the lateral openings between the bricks, in effect actually scrubbing the refractory surfaces with chemical solvents. The size and shape of the checkerworks seem to have no bearing on the effectiveness of the jet.

Dowell engineers have had extensive experience in cleaning industrial equipment with chemical solvents. Almost every piece of equipment found in blast furnace gas cycles and open hearth furnaces has been cleaned by Dowell. As a matter of fact, some have been cleaned while in actual operation.

Call a Dowell engineer to discuss your maintenance cleaning problems. He'll be glad to make a cost estimate on cleaning your equipment with chemicals. If you prefer, write directly to Tulsa, Dept. B-29.

DOWELL SERVICE

Over 100 Offices to Serve You with Chemical Cleaning for:

Boilers • Condensers • Heat Exchangers • Cooling Systems
Pipe Lines • Piping Systems • Gas Washers • Process Towers
Process Equipment • Evaporators • Filter Beds • Tanks

Chemical Services for Oil, Gas and Water Wells

DOWELL INCORPORATED • TULSA 1, OKLAHOMA

DOWELL

A Service Subsidiary of
THE DOW CHEMICAL COMPANY

Date-line Diary...

January 3

▲ The AISI reports that operating rate of the steel industry for the week starting January 3 is scheduled at 80.5 per cent of capacity. This is equivalent to 1,943,000 tons compared with 1,850,000 tons one week ago and 1,798,000 tons one year ago. Index of production for the week is 121.0.

▲ The steel industry began 1955 with an ingot capacity of 125,828,310 tons or almost 1,500,000 more tons than it had one year ago. Blast furnace capacity is 83,971,100 tons and new coke capacity is 72,604,750 net tons.

▲ Auto companies turned out a total of 5,510,669 autos for the year of 1954 compared to the 6,233,937 cars in 1953.

▲ Total manufacturers' sales for November amounted to $24,600,000,000, up $100,000,000 from October according to the Commerce Dept.

▲ Wheeling Steel Corp. will resume bessemer steelmaking operations this week at its Steubenville South Works, Mingo Junction, Ohio.

January 4

▲ United States Steel Corp. announced upward revisions averaging less than 1 per cent in its prices for certain grades of alloy and stainless steels containing molybdenum as a result of an advance in price of molybdenum.

January 5

▲ Wage and salary payments mounted to the yearly rate of $197,400,000,000 in November, up $1,300,000,000 from the October figure, according to the Commerce Dept. The greatest increase took place in the auto industry.

January 6

▲ A combination of four big American mining companies, American Smelting, Cerro de Pasco, Phelps Dodge and Newmont Mining formed the Southern Peru Copper Corp., to develop three Peruvian copper properties. American Smelting owns 57¾ per cent of this new company's stocks.

▲ The Commerce Dept. issued export licenses in December which covered 291,852 tons of scrap in December in comparison to 523,058 tons in November.

▲ Babcock and Wilcox Co. purchased Globe Steel Tubes Co. of Milwaukee, Wis., and plans to make the firm part of its tubular products division at Beaver Falls, Pa. The sale amounted to $9,300,000.

▲ The Board of Directors of A. M. Byers Co. and Erie Forge and Steel Corp. has agreed to merge the two companies providing stockholders approve. The merger will result in the establishment of the Byers-Erie Corp. with capital and surplus of $23,000,000.

January 7

▲ According to the AISI, average hourly wage paid in the iron and steel industry reached a high of $2.391 in November with total estimated payroll amounting to $247,722,000. Total estimated employment for November was 598,800 working 37.6 hr a week, compared with 596,100 in October.

January 8

▲ Tata Iron and Steel Co. of India will expand its capacity of 921,000 tons to 1,421,000 tons providing it can obtain the $100,000,000 required.

▲ Cia. Belgo-Mineira, in Latin America, is planning to build a large wire-drawing mill which will have an annual output of 100,000 tons.

January 9

▲ A spurt in the December total of contract awards in the 37 states east of the Rockies brought December total to $1,828,837,000 and total for year to $19,770,207,000 up 13 per cent over 1953.

January 10

▲ The Bureau of Mines predicts a new supply of 3,056,000,000 barrels of fuel in 1955 against 2,949,000,000 in 1954.

▲ NEMA expects volume of electrical manufacturing industry to hit $16,400,000,000 in 1955 compared to $15,600,000,000 in 1954.

▲ The AISI has placed the center of steelmaking about six miles south of Beaverdam, in Marion County, Ohio.

▲ The Aluminum Association reported primary production of aluminum in November 1954 totaled 242,503,923 lb compared to the 250,178,989 lb produced in October and 211,273,802 lb in November 1953.

▲ November sales of manufacturers, wholesalers and retailers totaled $48,800,000,000, $1,800,000,000 above the 1953 figure.

▲ The AISI reports that operating rate of the steel industry for the week starting January 10 is scheduled at 81.8 per cent of capacity. This is equivalent to 1,975,000 tons compared with 1,960,000 tons one week ago and 1,950,000 tons one year ago. Index of production for the week is 122.9.

January 11

▲ The Commerce Dept. reported U. S. exports of commercial goods during November totaled $1,135,000,000 or $105,000,000 above the same month one year ago but $28,000,000 under the preceding month.

▲ National Tube Div. of U. S. Steel Corp. began work on facilities at its McKeesport, Pa. plant to triple present production of deep-well casing.

▲ The AISI reported 1954 open hearth production was 80,327,290 net tons compared with 100,473,823 net tons in 1953, bessemer production was 2,547,978 tons, electric furnace was 5,430,311 tons for a total of 88,305,579 net tons. Production of pig iron and ferro alloys was 58,688,117 net tons.

January 12

▲ A recent report by an advisory committee stated that highway building expenditures covering the next 10 years should be around $101,000,000,000. Of this, Federal Government will finance about 30 per cent with the remainder being financed by state and local authorities.

January 13

▲ Ferrous scrap consumption during November totaled 4,932,000 gross tons compared to 4,782,488 tons in October according to the Bureau of Mines.

▲ A report of The Aluminum Association stated that primary aluminum production in the United States in December totaled 254,112,883 lb compared to 242,503,923 lb in November and 220,582,988 lb in December 1953. Total for year was 2,921,174,443 lb. Net imports in 1954 totaled 387,600,000 lb compared with 675,200,000 lb in 1953.

January 16

▲ Lukens Steel Co. reported a net income of $2,014,791 for 1954 compared to $3,607,713 in 1953, after provision was made for income taxes. Sales in 1954 were $74,954,710 in comparison with 1953's total of $97,850,937.

January 17

▲ Home buildings in 1954 rose to 1,215,000, up 10 per cent from 1953. Work in December was started on 91,000 dwellings, a new high for this month.

▲ FRB reported industrial production for 1954 averaged 125 per cent compared to the 134 per cent of the 1947-1949 level in 1953.

▲ The AISI reports that the operating rate of the steel industry for the week starting January 17 is scheduled at 82.4 per cent of capacity. This is equivalent to 1,989,000 tons compared with 2,007,000 tons one week ago and 1,766,000 tons one year ago. Index of production for the week is 123.8.

January 18

▲ The ARCI reported deliveries of new domestic freight cars in December totaled 2173 compared with 1302 in November and 4456 in December one year ago. Sales in December totaled 2685 cars leaving a backlog of cars on order as of January 1, 1955 of 15,317 compared with 14,805 on December 1, 1954.

January 20

▲ Baldwin-Lima-Hamilton Corp. has acquired Hydropress, Inc., and its subsidiary, Loewy Construction Co.

▲ Machine tool orders in December increased 76 per cent over November to $60,000,000, the largest in 15 months. New orders in 1954 totaled $560,000,000, 35 per cent below the $862,000,000,000 figure in 1953.

▲ The American Brass Co. a subsidiary of Anaconda Copper Mining Co. is planning to build a $25,000,000 aluminum mill on the outskirts of Terre Haute, Ind.

January 21

▲ On net sales of $20,412,223 for the year 1954, net income after taxes of $772,527 was disclosed by the Atlantic Steel Co.

January 22

▲ The Colorado Fuel and Iron Corp. announced earnings during the quarter ending December 31, 1954 of $1,637,789, after provision for Federal income taxes, equal to 55¢ per share on common stock. The six month period ending December 31, 1954 showed earnings of $3,056,524, after provision for Federal income taxes, equal to $1.03 per common share.

January 24

▲ The AISI reports that operating rate of the steel industry for the week starting January 4 is scheduled at 84.0 per cent of capacity. This is equivalent to 2,027,000 tons compared with 2,008,000 tons one week ago and 1,802,000 tons one year ago. Index of production for the week is 126.2.

January 25

▲ Republic Steel Corp. reported their sales for 1954 had declined to $852,000,000 which is 25 per cent less than in 1953. Net profits also dropped to $52,900,000 or $7.10 a share from $56,700,000 or $9.25 a share in 1953.

▲ Kaiser Steel Corp. announced operations for the six months ending December 31, 1954 resulted in a net loss of $710,744 in comparison with earnings of $5,417,919 or $1.33 per share on common stock for the same period one year ago.

▲ U. S. Steel Corp. announced a dividend of $1.00 per share of common stock which represented a 25¢ increase over the 75¢ which had been paid for each quarter since the third quarter of 1950. The Board of Directors also approved for submission to stockholders, a proposal that each presently authorized share of common stock be changed and reclassified into two shares of common stock having a par value of $16⅔ per share. Income for year totaled $195,236,672 or $6.45 a share on sales of $3,250,527,139, compared with sales of $3,861,034,728 and earnings of $7.54 a share in 1953.

▲ On net sales of $537,023,979, net earnings of $41,287,152 equal to $7.92 a share were disclosed by Inland Steel Co. in 1954 compared with 1953's figures of net sales of $578,610,625 and net earnings of $33,867,184 or $6.90 a share.

January 26

▲ AISC reports shipments of fabricated structural steel in December were 223,533 net tons which brought the 1954 year's total to 3,135,525 net tons in comparison with 1953 when 3,117,711 net tons were shipped. Orders in December totaled 196,767 tons giving a 1954 total of 2,509,817 tons. Backlog of work on December 31 totaled 1,200,882 tons.

January 27

▲ The 1954 net income for Jones and Laughlin Steel Corp. was $25,032,000 or $3.80 a share of common stock on sales and operating revenues of $492,941,000 compared with 1953's net income of $31,015,000 or $4.77 a share of common stock on sales and operating revenues of $624,387,000 in 1953.

▲ Wheeling Steel Corp. reported gross sales for 1954 totaled $187,571,957 with a profit of $9,595,740 or $5.48 per common share compared with 1953's gross sales of $217,356,078, and profit of $12,458,311 or $7.49 a common share.

▲ Bethlehem Steel reported net profits for 1954 of $13.18 a common share down very slightly from the $13.30 earned in 1953. A dividend of $2.25 was declared payable March 1 compared with $2.00 paid for this period last year. On total billings of $1,656,809,455, Bethlehem Steel Co. declared a net income of $132,837,154 for 1954 in comparison with net billings in 1953 of $2,082,025,788 and a net income of $133,947,837.

January 28

▲ Granite City Steel Co. announced its profits for 1954 totaled $4,012,000 equal to earnings of $2.04 per share on common stock on net sales of $69,300,000 as compared to 1953's profits of $6,488,000 or $3.55 per share on net sales of $87,800,000.

January 31

▲ National Steel Corp. reports net earnings for the year ending December 31, 1954, after all charges, of $30,334,871 equal to $4.12 per share compared with the previous year's net earnings of $49,174,080 equal to $6.68 per share. Total sales and operating revenue in 1954 amounted to $484,058,380 compared with $634,178,060 in 1953.

▲ Armco Steel Corp. reported 1954 net income of around $41,000,000 or about $7.83 per share on common stock on total sales of $531,206,000, in comparison with a net income of $33,906,462 or $6.50 per common share on total sales of $588,919,900 in 1953. The board approved a 2 for 1 stock split.

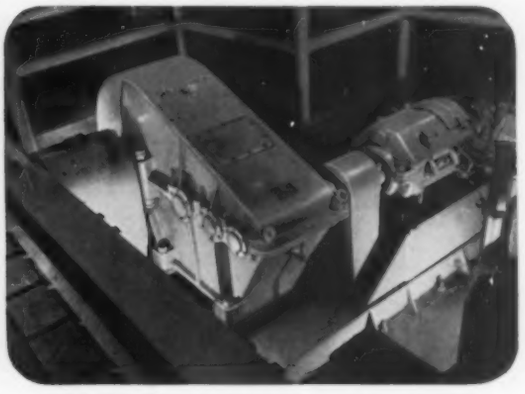
▲ The AISI reports that operating rate of the steel industry for the week starting January 31 is scheduled at 85.4 per cent of capacity. This is equivalent to 2,061,000 tons compared with 2,051,000 tons one week ago and 1,774,000 tons one year ago. Index of production for the week is 128.3.

▲ Production of slab zinc in smelters in 1954 totaled 868,247 tons in 1954 compared with 971,191 tons in 1953.

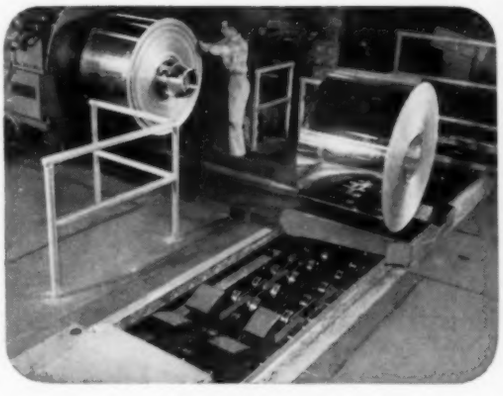
How LINK-BELT serves J & L

AT PITTSBURGH

This double-strand Link-Belt coil conveyor, one of two at Pittsburgh works, easily handles coils weighing up to 60,000 pounds.

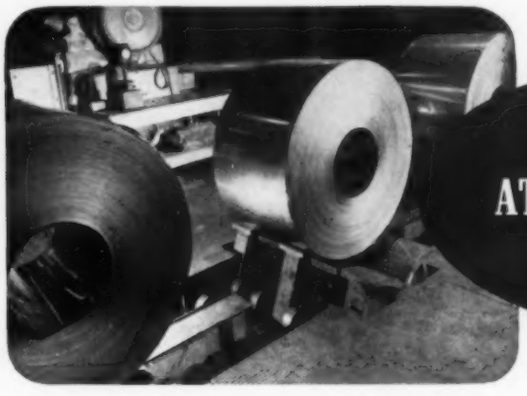


Parallel shaft drive provides efficient speed reduction. Jones & Laughlin relies on Link-Belt equipment throughout their mills.



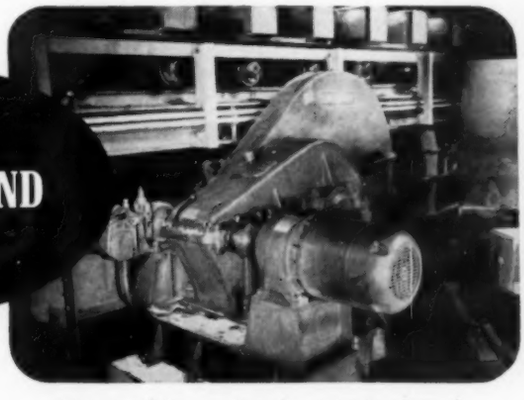
At entry to shear line, up to 72-in. coils are lifted from Link-Belt saddle-top conveyor to pay-off reel by hydraulic buggy.

AT ALIQUIPPA



Precise weights of up to 40,000-lb. coils are recorded as they move along Link-Belt conveyor at temper mill delivery end.

AT CLEVELAND



Booster drive at J & L's Cleveland works includes Link-Belt Electrofluid, parallel shaft gear and precision steel roller chain drives.

Yield goes up, waste goes down on the 77-in. hot strip mill served by Link-Belt car-type conveyor. Coils are moved gently, safely.

LIKE so many other leading steel mills, Jones & Laughlin has used Link-Belt conveying and power transmission machinery for many years. In addition to handling coils, Link-Belt conveyors assure economical movement of materials in every step of steel making, from raw materials to finished product. Next time you're in the market for a single conveyor or a complete system—call the Link-Belt office near you. We're sure you'll like the expert engineering cooperation promptly available to you.

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MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION EQUIPMENT

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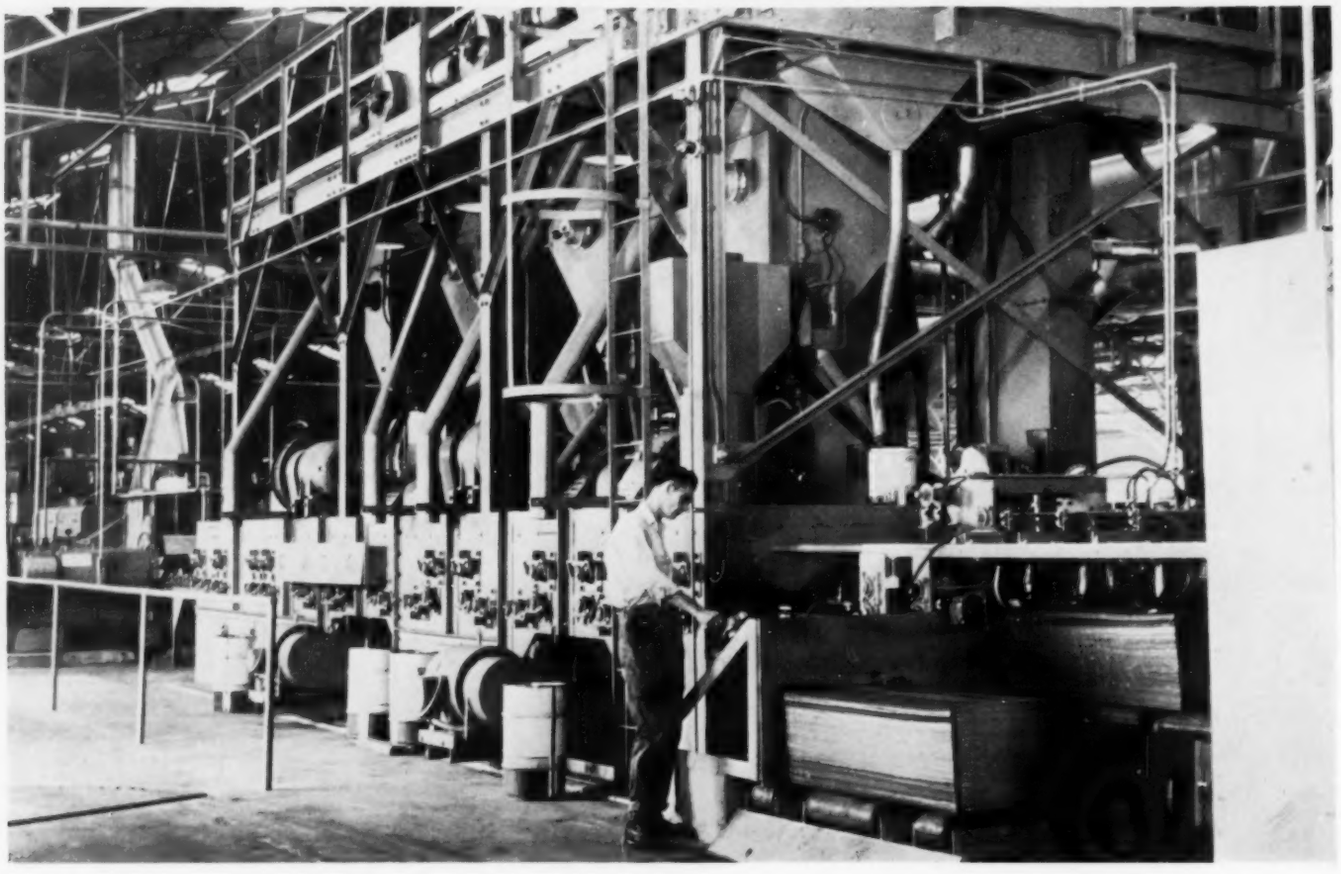
pioneering developments keep WHEELABRATOR® first in blast cleaning



How WHEELABRATOR® MECHANICAL CLEANING

of Hot Rolled Steel Sheets Reduces Cleaning Costs per ton.

Operating results of airless Wheelabrator mechanical cleaning equipment for removing scale from hot rolled steel sheets have proved that other methods do not equal its cost-cutting performance and high speed cleaning efficiency.

In each of the seven drum plants of Rheem Manufacturing Co., for example, Wheelabrator machines have greatly reduced the cost of cleaning 18-gauge steel sheets used in the manufacture of their new Rheemcote lithographed steel drums. In other steel processing plants and steel mills, the Wheelabrator is also effecting impressive results in low cost, high production and providing extra benefits in improved surface cleanliness and better working conditions.

These production economies are a result of perfected equipment design coupled with the controlled abrasive blast of the Wheelabrator unit. With the introduction of Wheelabrator Steel Shot, equipment operating and maintenance costs are extremely low and continuous, high-production mechanical cleaning of hot rolled products is now in actual practice.

We would be glad to demonstrate the savings the Wheelabrator can make for you. Write today for full details and an appointment to see the Wheelabrator in operation.

Bulletin 894 describes the descaling of Steel Strip and Bulletin 914 describes the descaling of steel sheets. Send for your copies today.

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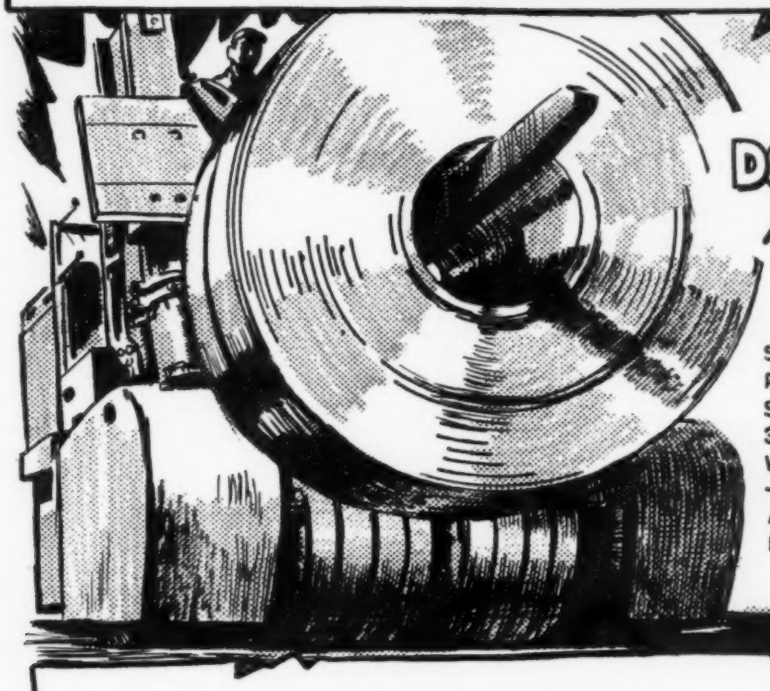
AIRLESS BLAST CLEANING

FACTS ABOUT Exide®

IRONCLAD® INDUSTRIAL TRUCK BATTERIES



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STEEL MILLS USE GIANT EXIDE-POWERED RAM TRUCKS TO HANDLE HUGH COILS OF SHEET STEEL WEIGHING AS MUCH AS 30 TONS EACH. THEY WORK FULL-SHIFT WITHOUT COSTLY DOWN-TIME DELAYS -AROUND THE CLOCK. EXIDE DEPENDABILITY AND EXCEPTIONALLY LONG USEFUL LIFE RESULTS IN LOWEST HANDLING COSTS PER TON.

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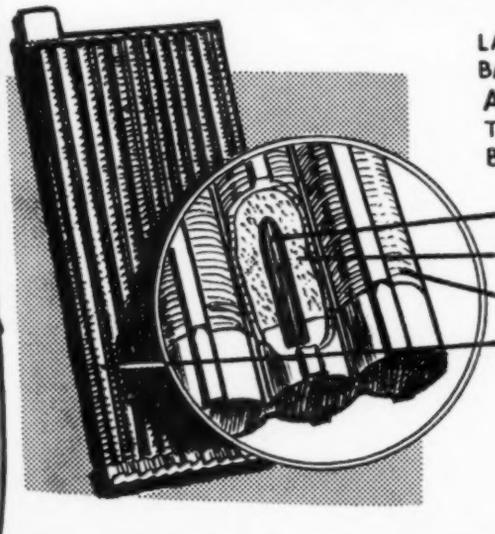

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- PROTECTED CONDUCTING GRID
- COMPRESSED ACTIVE MATERIAL
- SLOTTED RETAINER TUBE
- IRONCLAD POSITIVE PLATE

EXIDE-IRONCLADS ARE YOUR BEST POWER BUY **AT ANY PRICE!**

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Exide INDUSTRIAL DIVISION, The Electric Storage Battery Company, Philadelphia 2, Pa.

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cast in nickel UNIVAN steel

you can double the life of your charging boxes with univan castings

Are you having trouble with excessive firecracking, distortion or breaking of your present charging boxes? If so, you may well find that a switch to UNIVAN charging boxes is the answer. For actual performance has shown that they can give you double the life of ordinary castings.

You'll find, for example, that nickel UNIVAN steel castings . . . as compared with carbon steel castings . . . have greater resistance to firecracking and to torsional twist and shock.

And that applies also to peels, bearing covers, couplings and spindles, tongs and tong levers . . . all of them available in this special alloy steel.

We'll be glad to send you more complete information on UNIVAN castings. Or, to quote from your blueprints on your requirements . . . for castings in the rough or completely machined.

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UNION PRODUCTS: charging boxes • peels • bearing covers • slag pots • tongs and tong levers • universal couplings and spindles • gears and pinions • ingot cars • charging box cars • special UNIVAN and ARMOR steel castings

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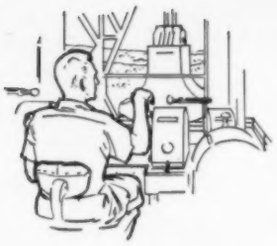

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15-Ton unloaders with EC&M control set new records in unloading time and low maintenance costs at the Baltimore & Ohio, Curtis Bay Ore Pier

20,560 TONS OF IRON ORE UNLOADED IN 13 HOURS AND 55 MINUTES! Fast-operating EC&M Line-Arc Contactor Control with EC&M Time-Current Acceleration helped establish this record.

EC&M Control Apparatus and Control Engineering also provide outstanding safety during all operations. Power for motor drives is fed through operator's cab for safe, direct control. Dynamic braking for quick trolley stop is automatically applied in end-zones and if power fails. EC&M Quadruplex Controllers insure that the 4 bridge motors share the load equally and that brakes release and set uniformly.

Replacement part cost, in this installation, has been only 25¢ per 1000-tons of ore unloaded over a 3 year period. The record proves that high output with low upkeep is yours when you select EC&M Control.

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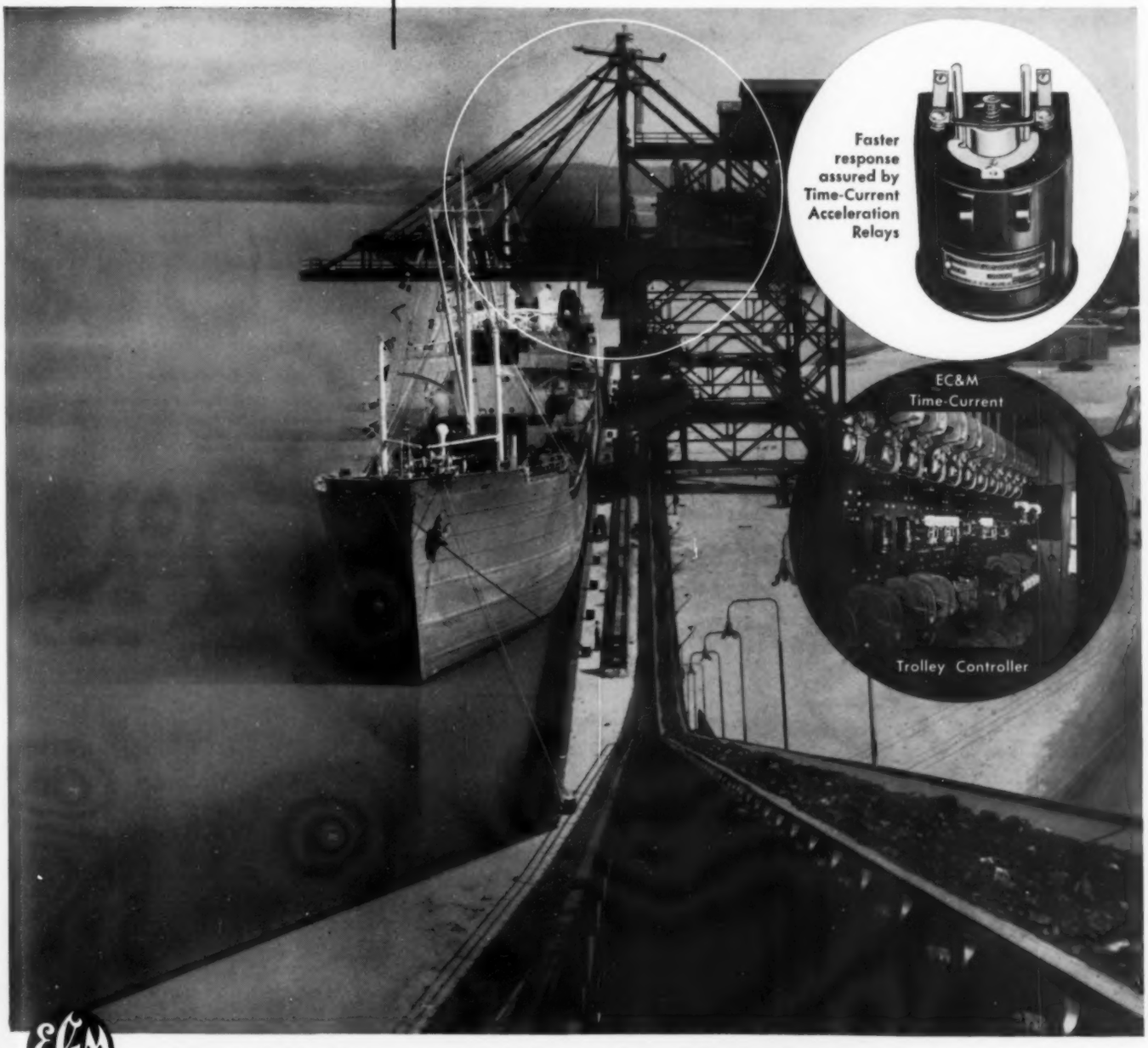

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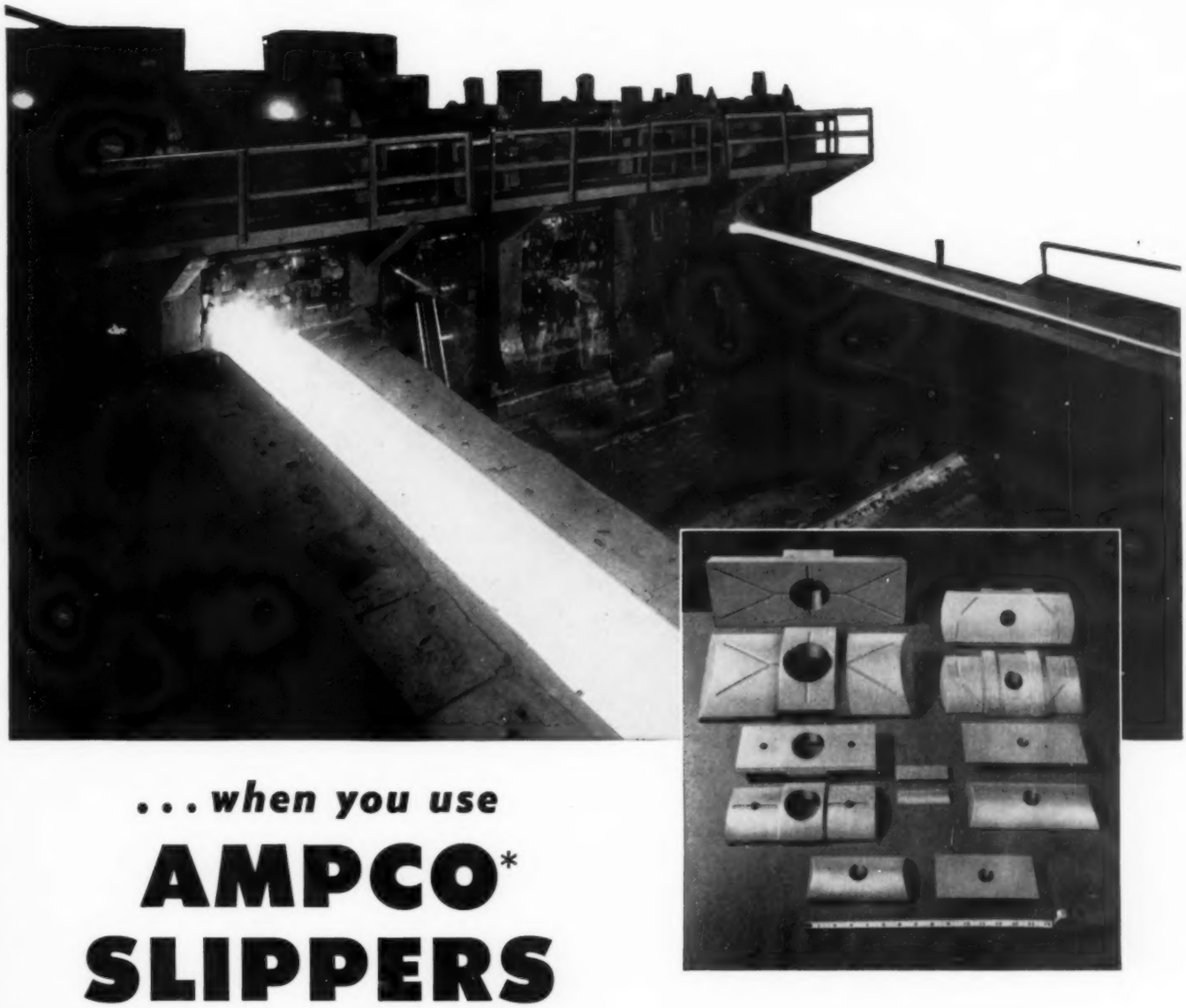
The Cities Service Heat Prover is not a product you buy, but a service we supply . . . free! For more information, contact your nearest Cities Service office or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

Production Steps Up Costs Step Down



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THERE'S plenty of "plus value" in slippers cast of Ampco Metal. They're tough — have unusual resistance to wear. They withstand the tremendous impacts and shock loads of steel-mill operation without squashing out. They have high fatigue strength.

These properties mean lower costs for you — less downtime — longer runs without replacement.

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And that's not all. Ampco Metal's stamina, toughness, and corrosion resistance mean that it's ideally suited for cutting costs in other steel-mill applications, too — screw-down nuts, wear plates, flash-welder dies, pickling equipment. Get the whole money-saving story from your nearby Ampco field engineer or write us direct

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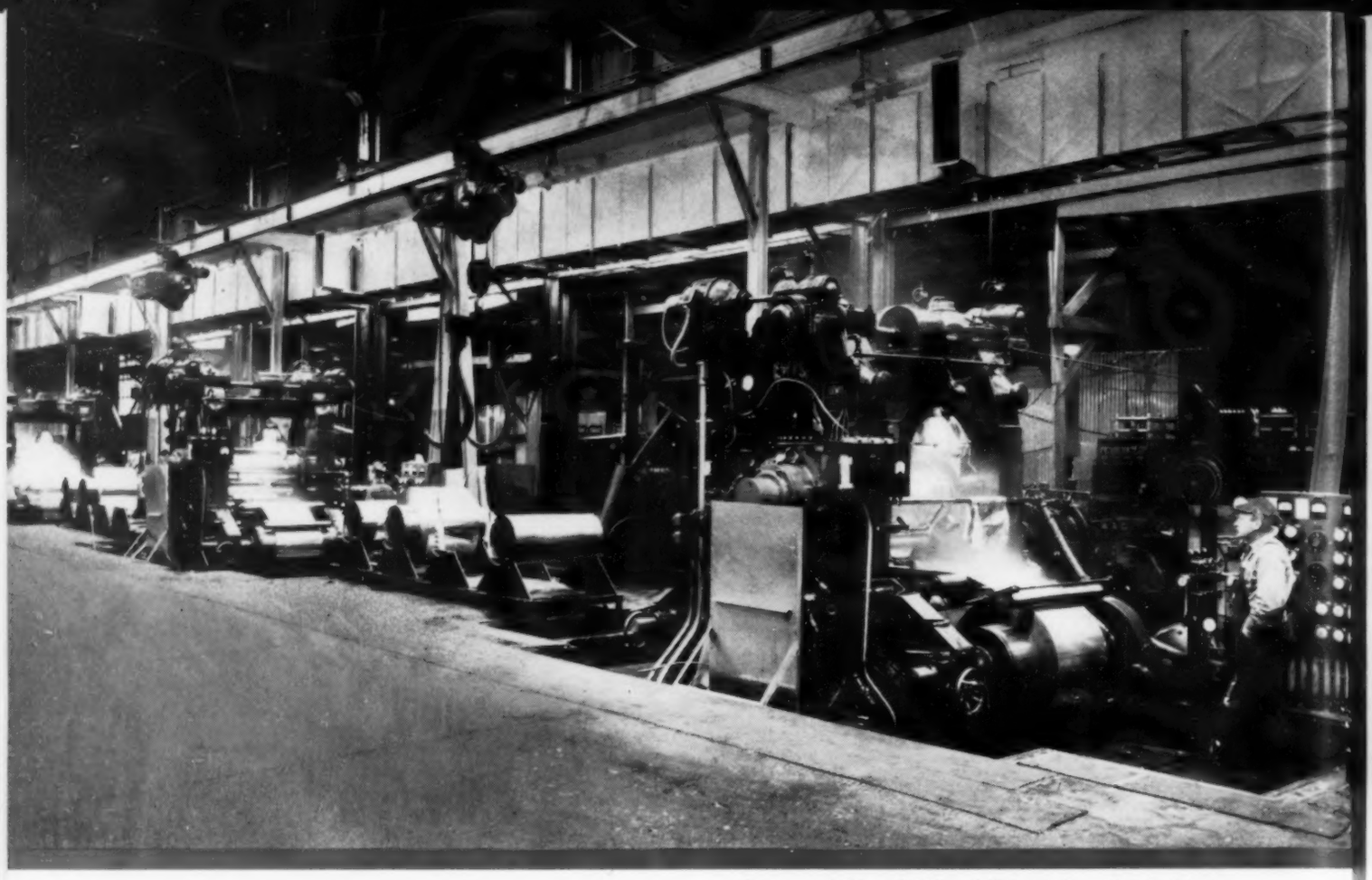
West of the Rockies it's Ampco's Burbank Plant, Burbank, California



battery of 9" and 21" x 44" Lewis four-high Foil Mills

. . . high production mills roll foil at speeds up to 4000 fpm

Whether you want to start with an ingot from a hot mill or start with coils, you can get a full range of Lewis equipment, designed and built to meet your specific requirements. Over one hundred modern Lewis Foil Mills, for example, are now successfully operating in plants of the country's top ranking aluminum foil producers.

Built in various sizes and widths to meet individual customer requirements, these Lewis Foil Mills include the latest design in bearings, electric tension control, thermal control and handling equipment. They usually start with .030" or .026" sheet and can reduce down to .00025" . . . at speeds ranging from 1000 to 4000 feet per minute.

So call us in the next time you're in the market for a mill to roll aluminum. Our engineers, who have had extensive experience in the development of high speed mills, will study your requirements with you. This experience plus modern manufacturing facilities will assure you of getting the type of equipment best suited to your specific needs.

LEWIS four-high FOIL MILL

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LEWIS PRODUCTS: Two-High Mills • Three-High Mills • Four-High Mills • Strip Mills • Bar, Billet and Structural Mills • Plate Mills • Rod Mills • Coilers • Tables • Shears • Pinion Stands • Gear Drives • Roll Lathes

Industry News...

WEIRTON STEEL CO. BUILDS SINTERING PLANT AND WET FLUE DUST RECLAMATION UNIT

▲ A modern sintering plant and wet flue dust reclamation unit, incorporating new operating techniques for the production of high-quality sinter, is now under construction at Weirton Steel Co.

The new plant will occupy a site 200 x 600 ft in the Steel Works Department and will have a rated capacity of 2,000 tons of sinter per day. Building steel for the unit is now being erected.

A flue dust recovery system will be installed for the clarification of blast furnace gas-washer water presently being discharged into the Ohio River. The flue dust sludge recovered in this operation will be used in the sinter plant operation. The water clarification system will enable Weirton to eliminate the discharge of blast furnace dust into the Ohio River.

The new plant will convert the fines from Labrador and Mesabi ore into an agglomerated product. The ore fines, which would normally tend to blow out of the top of the blast furnaces along with gases, will be made into the high iron content material that can be readily smelted into iron in the furnaces.

In the operation, ore buckets will pick up the iron ore from stockpiles and load it into ore transfer cars on the blast furnace high line. The ore will then go into track hoppers from which it will be transported by belt conveyors to the upper floor of the sinter building where the coarse and fine materials will be separated by vibrating screens.

The coarse material will go by belt conveyor to a 500-ton storage bin above the high line where it will be picked up for delivery to the various blast furnace bins in the transfer cars returning from the track hoppers.

After the ore fines have been separated on the vibrating screens, they will be discharged into several 500-ton storage bins and from there will go onto a belt conveyor together with the flue dust and coke breeze. This feed mix will then be conveyed to pug mills where it will be mixed and prepared for sintering.

Next a belt conveyor will deliver the feed mix from the pug mills to the feeder on the sinter machine proper. The sintering machine is a traveling grate eight ft wide and 100 ft long on which the ore—flue dust—coke mixture is burned by down draft and sintered into the agglomerate product.

The hot sinter will then be discharged to a cooler, and from there will go by belt conveyor to a second 500-ton storage bin over the high line.

COMPLETE FIRST PHASE OF RAIL MILL EXPANSION

▲ First phase of the rail mill improvement program at the Edgar Thomson Works of United States Steel Corp. was completed February 3, with the plant's third new rail end hardening facility in operation.

With the new unit in production, the rail mill will be able to end harden one steel rail every 90 seconds, heat treating eighteen 39-ft rails at a time. Two similar units, installed during 1954, were set up to end harden 12 rails at a time.

Need for end hardened rails has developed because of the heavier and faster rolling stock now in use by the nation's railroads. With the steel rails end hardened, they are better capable of taking the continual pounding of both heavy and high speed freight and passenger traffic.

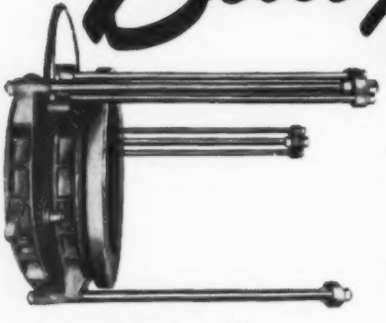
The wear in rails is greatest at the ends where they are joined by joint bars. It is at this point that the end hardening takes effect, resulting in more serviceable and longer lasting steel rails. Another important result of this process is a more comfortable ride for passenger traffic.

The new installation consists of four pre-heat burners using natural

REBUILD COKE BATTERY NO. 3 AT CLAIRTON WORKS

Workmen set steel reinforcing bars for the concrete foundation of No. 3 coke battery — one of three now being rebuilt at U. S. Steel's Clairton Works. Steel weather sheds provide shelter as they rebuild Nos. 1, 2 and 3 coke batteries at the world's largest coke plant. The new units bring to 17 the number of batteries reconstructed at Clairton since the war.

Bailey thermal expansion
GOGGLE VALVES



One of nature's most dependable forces—the linear expansion and contraction of steel—frees and clamps the goggle plate of these valves. Steam applied to three sets of tubes causes expansion which frees the goggle plate for swinging to either open or closed position. When steam is removed, contraction of the tubes forms a tight, safe, leakproof seal. Can be operated by hand in case of steam failure.

Made in sizes from 36" to 120" in diameter for horizontal or vertical gas mains.

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gas, one super-heat burner, a forced air quench which cools the hardened ends before transfer to the inspection tables and auxiliary equipment.

J&L OPENS CONTAINER PLANT AT LANCASTER

▲ Jones & Laughlin Steel Corp.'s Warehouse-Container Division Plant at Lancaster, Pa., was opened officially on January 25. The opening marked another step in J&L's post-World War II expansion and improvement program, which by the end of 1955 will have cost over a half-billion dollars. Plant includes a new 400-ft building, with 100,000 sq ft of floor space, divided about equally between a warehouse serving steel customers, and the container division plant. The container division plant manufactures steel shipping pails.

The new J&L warehouse carries a complete line of steels including structural shapes, hot rolled bars, angles, plates, hot rolled sheets, cold rolled sheets, reinforcing bars and cold finished bars. It is equipped to cut all types of steel to the customers' specifications.

The Lancaster warehouse brings the total number of J&L warehouses to 10. It is the third warehouse to be added to J&L's Warehouse Division in the past 20 months.

F. J. COLLIN, A.G., NAMES MELLON-STUART AGENT

▲ American rights to patents and processes of a German firm which is one of the world's oldest designers and builders of coke ovens and accessory equipment has been acquired by Mellon-Stuart Industrial Construction Co.

E. P. Mellon, II, chairman of the board of the parent Mellon-Stuart Co., said the agreement entered into with F. J. Collin, A.G., of Dortmund, Germany, makes his firm's industrial subsidiary exclusive agent for Collin's patents in the United States and the rest of North America.

The agreement makes available engineered coke oven, coke gas desulphurization and by-product facilities and processes evolved by Collin, which has a history dating back more than 100 years.

Robert L. Clark, general manager of Mellon-Stuart Industrial Construction Co., said:

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Roller Ends

RIGHT ANGLE
Bearing Surfaces

RIGHT ANGLE
Separator Slots

Longer operating life? Right!
Less maintenance? Right again!

Heavy-duty equipment "rolls right" with Rollways because . . .

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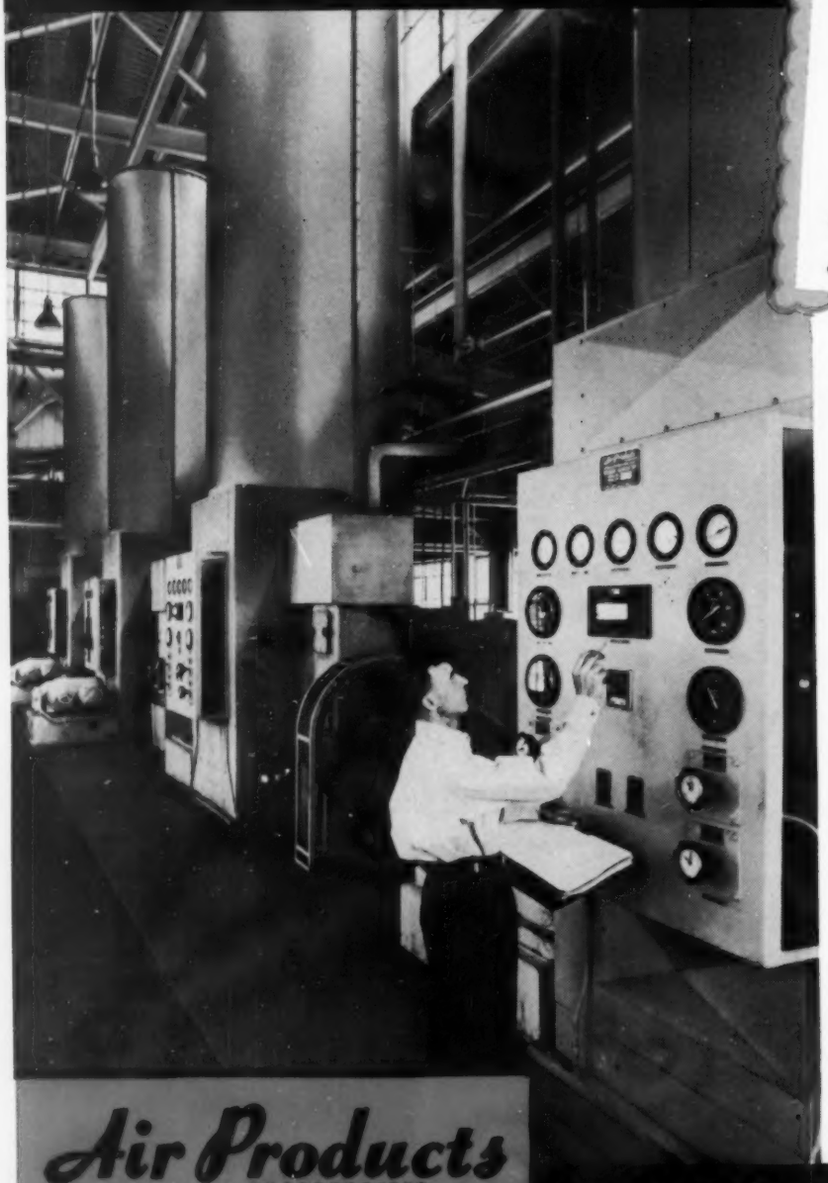
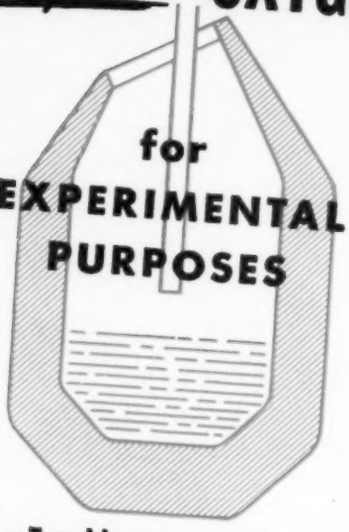


Surplus OXYGEN



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"This German company also has developed a revolutionary, new method for treating waste pickle liquor that should be the answer to many of the problems that have confronted the basic steel industry for years. The Collin method recovers all the chemical components of the waste so that they can be re-used or sold competitively on the open market and the installation will pay for itself in a few years, depending on market conditions."

Collin is best known for its design of coke ovens, which differ basically from those used in this country because of the firing method. For 40 years, Collin has designed ovens which heat with fresh fuel alternately from the bottom, then the top of the oven. The Collin firm guarantees more uniform heating with less fuel consumption, better quality coke and increased by-products, longer oven life and lower initial installation costs because of simplicity of design.

"We made an intensive study of Collin coking installations in Europe and found that they are about 15 per cent more efficient than anything we have in this country," Clark said. "We are confident the proven superiority of these processes will gain wide acceptance here as they have in other parts of the world."

Clark said installation of Collin ovens or other equipment made by Mellon-Stuart Industrial Construction Co. will conform with standard U. S. practices and all equipment will be designed and manufactured in this country.

ATLANTIC STOCKHOLDERS OK EXPANSION PROGRAM

▲ A $10 million modernization and improvement program at Atlantic Steel Co. has been approved by stockholders.

In a message to stockholders, contained in the company's 1954 annual report, R. S. Lynch, president of the Atlanta firm, recommended: (1) the construction of a new merchant bar and rod mill at an estimated cost of $8,735,000; (2) a second electric furnace at an estimated cost of $750,000; and (3) construction of a new administration building at a cost of approximately $450,000.

The proposed new bar and rod mill will substantially increase the company's productive capacity, product range and sales potential. Atlantic Steel's present bar mill was built in 1904. Products made on the mill have been a mainstay of the Dixisteel line for 50 years.

Atlantic has spent approximately $6 million on post-war plant modernization and expansion, all of which was done without additional equity capital. Improvements include installation of an electric furnace, re-equipping and modernization of the wire and nail mills, installation of additional galvanizing equipment, and establishment of a modern Warehouse Division. Construction is currently underway to expand the Warehouse Division facilities at a cost of about $275,000.

GARY PLANT SHIPS FIRST ORDER OF PLASTIC PIPE

▲ First order of plastic pipe manufactured at the Gary, Ind., plant of United States Steel Corp.'s National Tube Division was shipped January 17. The order consisted of two-in. and three-in. flexible pipe to be used for mine drainage.

Construction of the Gary plastic pipe plant began in June, 1954 and production was started the first of October. Initial production will be made from polyethylene in sizes ½ in. to six in. Manufacturing facilities have been established consisting of screw-type extruders, auxiliary and testing equipment which will eventually permit the manufacture of pipe from other plastic materials and in a greater size range.

KAISER TO BUILD BASIC REFRACTORIES PLANT

▲ The Chemicals Division of Kaiser Aluminum & Chemical Corp. will build a $4 million plant to produce basic refractories at Columbiana, Ohio.

Construction of the plant will begin early in April, and is scheduled to be in operation late in the year.

The plant, expected to employ about 100 people, will have more than three acres under roof plus a separate administration building. Included will be facilities for receiving and storing raw materials; grading, drying, classifying and mixing ingredients; pressing, drying and burning

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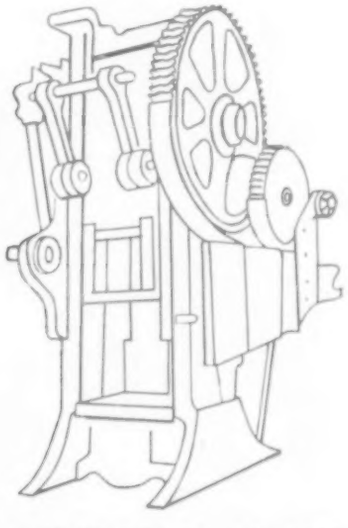

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brick, and packing and shipping the finished products.

There will also be an extensive laboratory for quality control. Machine shop facilities for servicing the plant and equipment will also be provided.

Production, which will be concentrated on basic brick, will be divided between the high magnesia periclase, periclase-chrome and chrome-periclase types.

Building of the Columbiana Works will be the third major plant addition in the East for Kaiser Aluminum & Chemical Corp. within recent months. The corporation will soon begin construction of a multi-million dollar aluminum sheet and foil rolling mill at Ravenswood, W. Va., which will be completed by mid-1956. Last fall Kaiser Aluminum acquired under lease an aluminum forging plant at Erie, Pa.

SPANISH BLAST FURNACE TO BE BUILT BY KOPPERS

▲ Contract for the design, engineering and procurement of certain equipment in the construction of the largest blast furnace in Spain was awarded to Koppers Co., Inc., according to an announcement by George M. Carvlin, vice president and general manager of Koppers Engineering and Construction Division.

Part of a large integrated steel mill, the blast furnace will be built at Aviles, Spain, on the Coast of Biscay, by the Empresa Nacional Siderurgica, S. A., a government-operated company.

TIMKEN TO LENGTHEN GAMBRINUS PIERCING MILL

▲ A $360,000 steel mill expansion program has been announced by John Fick, vice president at Timken Roller Bearing Co.'s Steel Division. The Gambrinus piercing mill will be lengthened to pierce tubing from 50 to 130 per cent longer than lengths presently processed there.

Completion date will be sometime in the late summer.

Future Meetings

▲ The second annual Western Plant Maintenance and Engineering Show is scheduled for July 12-14, at the Pan Pacific Auditorium in Los Angeles, Calif.

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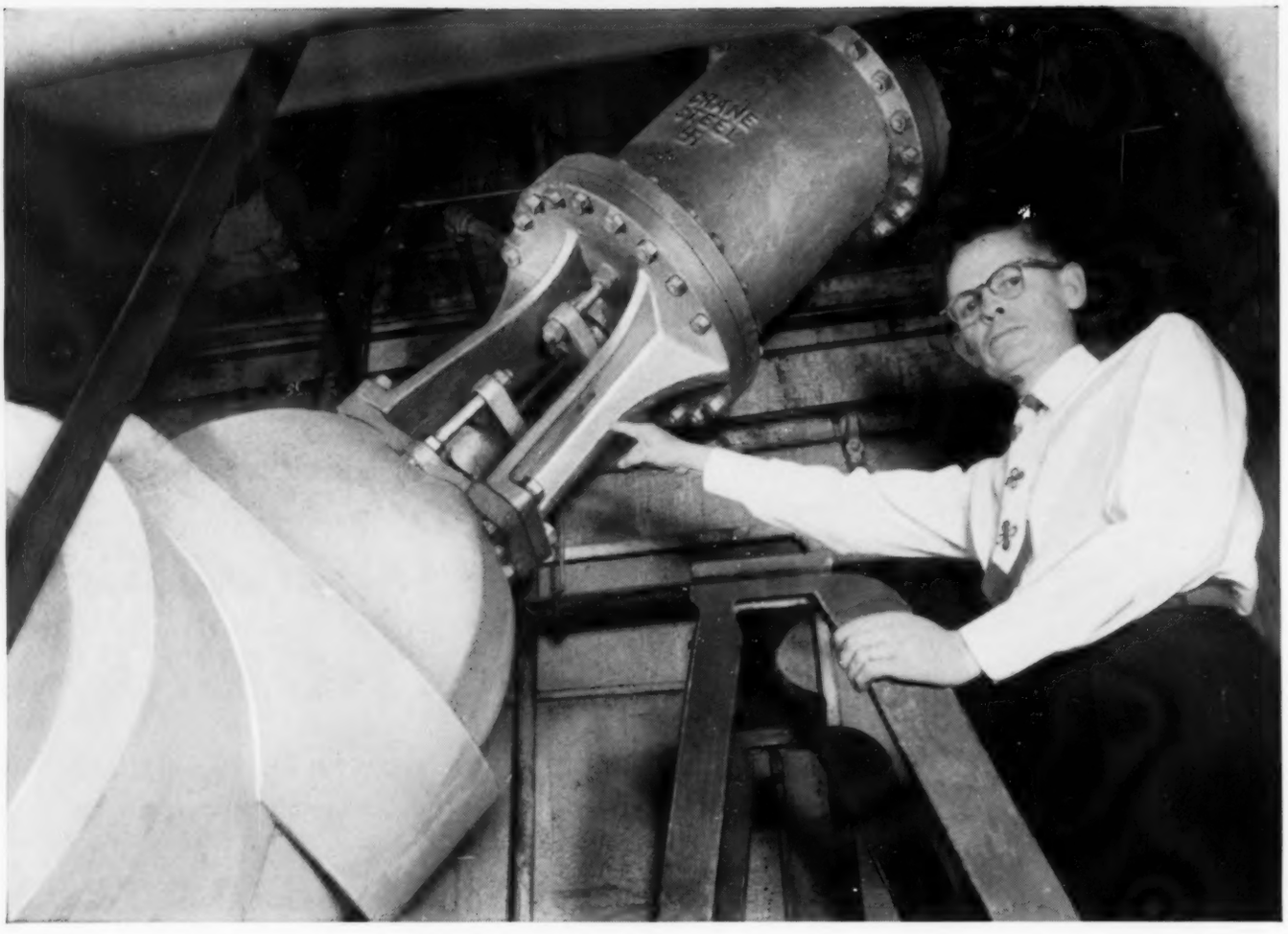

This CRANE VALVE begins new life after 37 years' service!

THE CASE HISTORY—World War One still raged when Cincinnati Gas & Electric Co. installed this Crane steel gate valve in 1917 at its Front & Rose Street Station. Ever since, it has safely controlled the main steam lead to No. 1 turbine—always making tight closure when needed—always responding smoothly to its hydraulic operator. For 37 years it has given such service with no more than routine maintenance—under operating pressure of 250 psi at 600 deg. F.

In 1954, the No. 1 turbine was renewed. The Crane steel valve—with complete confidence in Crane durable quality as demonstrated—was given limited preventive maintenance while down, and reinstalled in its original location.

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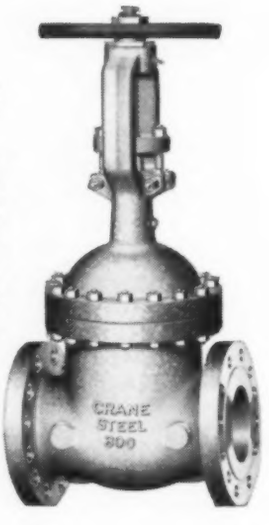

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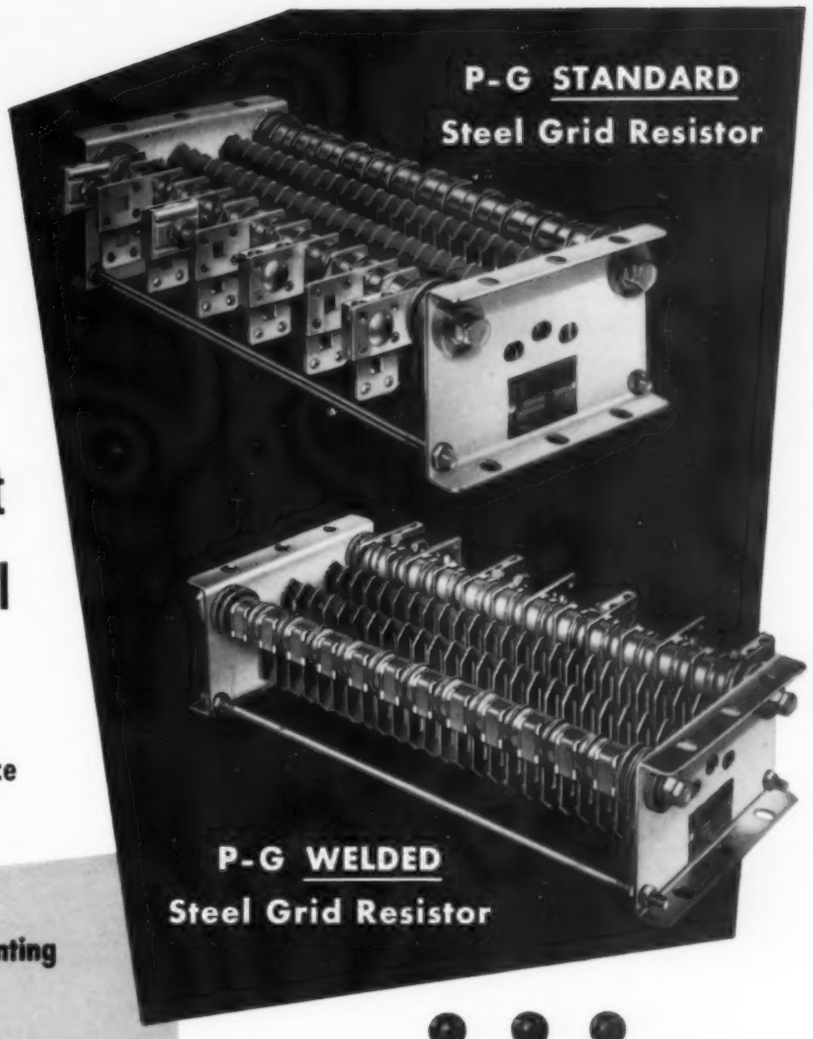

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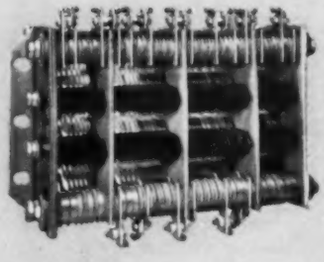

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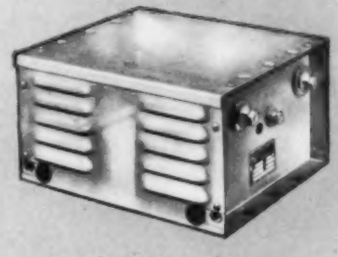

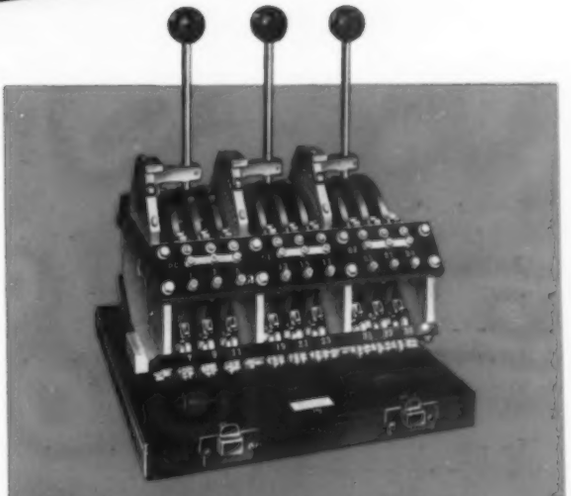

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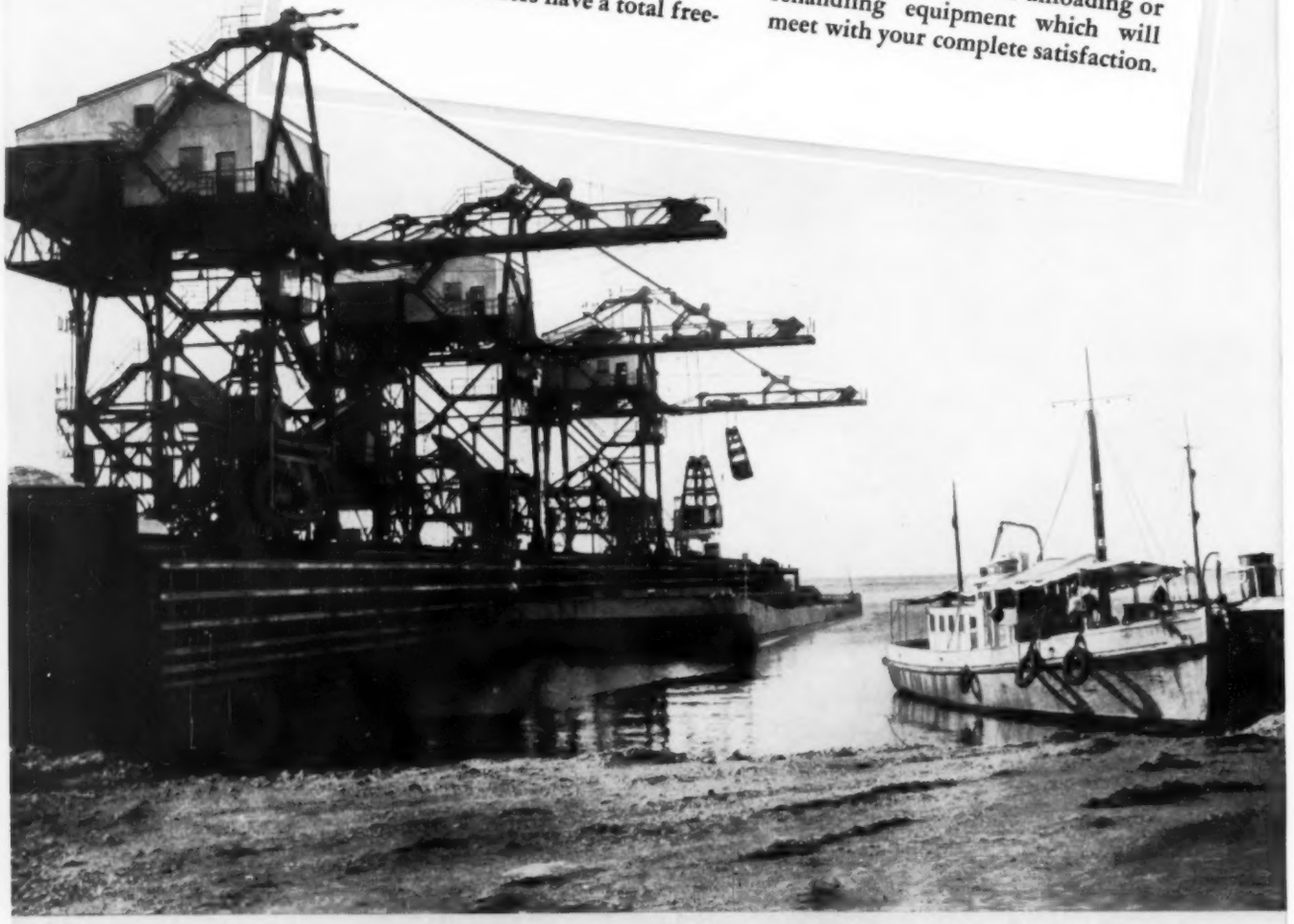
Unloading Venezuela Ore

These three Mead-Morrison unloaders, installed in 1949 at Puerto de Hierro, Venezuela, are a vital link in the material handling system transporting ore from the mine to steel plants in the U. S. The towers unload ore from river boats on the Orinoco River and deposit it on conveyor belts which transport the ore to stock piles to await shipment on ocean-going vessels.

The 8-ton unloaders have a total free-digging capacity of 3,000 tons per hour and were built of special alloy steel, to reduce weight and withstand earthquake shocks which occasionally occur in this locality.

Whatever your particular conditions may be, you can depend upon Mead-Morrison experience and engineering skill to design material unloading or rehandling equipment which will meet with your complete satisfaction.



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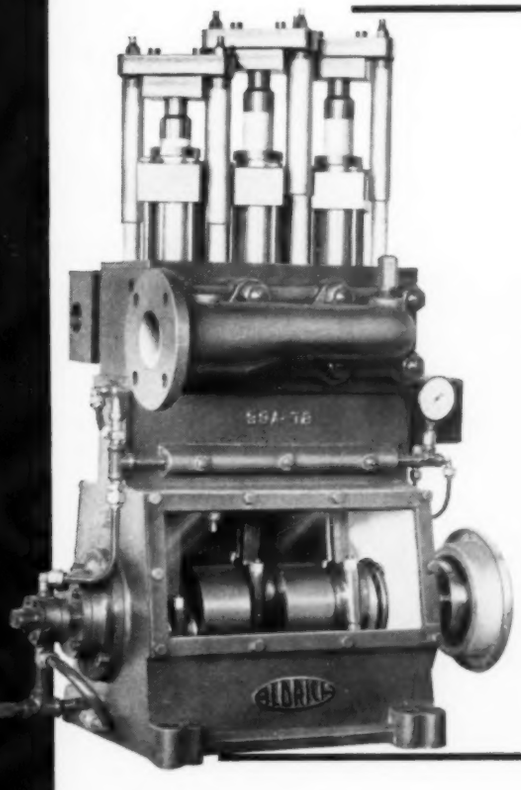

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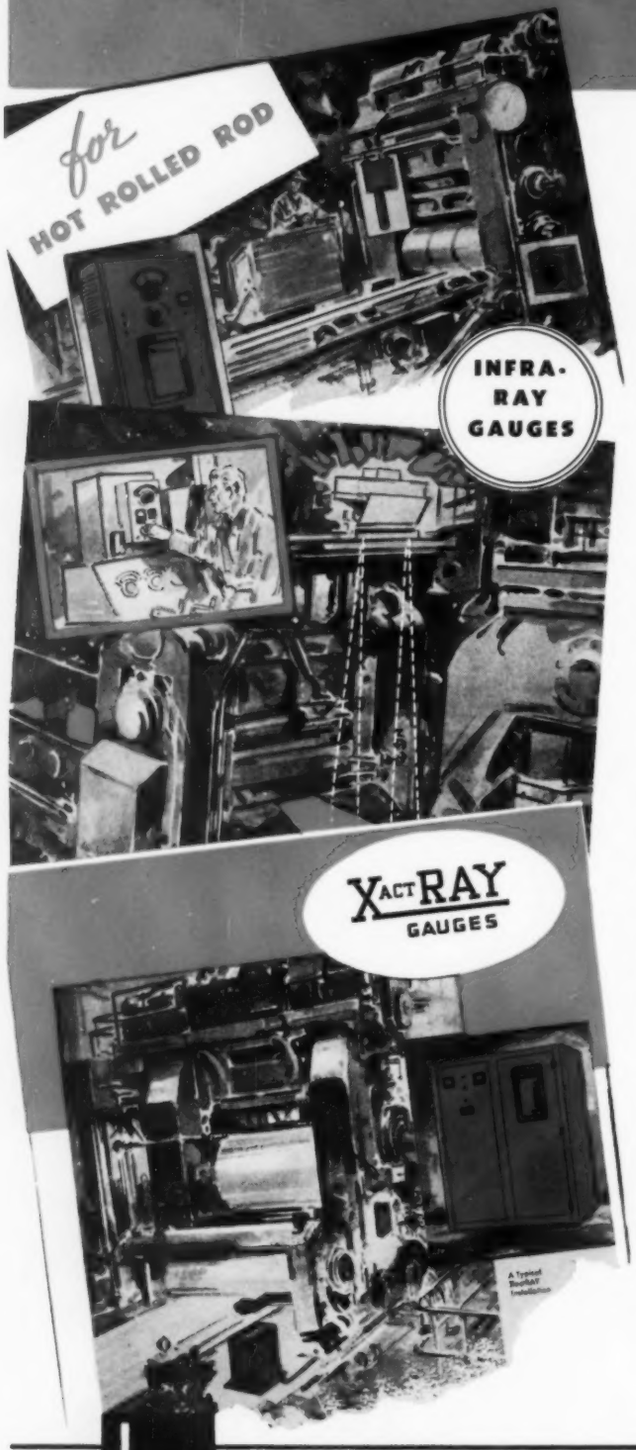
Cut Mill Costs

WITH MODERN NON-CONTACT GAUGES



HOT STRIP WIDTH

THE INFRA-RAY WIDTH GAUGE

A continuously indicating non-contact gauge operated by radiation from the material being measured—hot strip, plate, skelp, band, bar, shapes, or tubing.

On hot strip finishing stands it is not simply a width indicator. It provides a responsive method of making width by use of *controlled tension.*

This INFRA-RAY Width Gauge reduces trim scrap, avoids hold-back orders to replace a too-narrow coil, and holds mill edge material to closer tolerance.

HOT OR COLD STRIP THICKNESS

THE XactRAY THICKNESS GAUGE

An X-ray operated gauge for non-contact, accurate, continuous indication of strip thickness. A trouble-free, non-mechanical, simply-operated thickness gauge that can be adapted to any size or type of rolling mill and mounted close to the rolls.

THE XactRAYMATIC CONTROL

Electronic equipment for automatic strip thickness control—operated by the signal of the X-ray Gauge. Limits thickness deviation of strip from single stand mills or from the first stand of tandem mills by control of roll screw-down motors. Additional equipment can be provided to control thickness automatically by the same means used manually in the remaining stands, with no change of present mill controls.

This XactRAY Thickness Gauge permits you to accept orders with tolerances impossible to meet by hand control, increase speed of rolling, reduce scrap and returns.

HOT ROLLED ROD DIAMETER

THE INFRA-RAY DIAMETER GAUGE

For continuous measurement of the diameter of hot rolled wire rod as it emerges from the mill. The infra-red radiation of the rod itself supplies the operating signal to the gauge head which is mounted several feet from the rod.

This INFRA-RED Diameter Gauge will not only measure diameter continuously but will also detect lean rod, overfill, squashouts, and crossed rolls.

IGC **INDUSTRIAL GAUGES CORPORATION**

ENGLEWOOD, NEW JERSEY

Write for Details

Cut Mold Core Cleaning Time 2/3 by Powder-Lancing

Typical conditions of splashed metal, sand, and slag which have penetrated this ingot mold core.

This job was accomplished in 8 hrs., while previous lancing methods required up to 30 hours.

The time required to clean away splashed metal, sand, and slag which have penetrated these ingot mold cores has been cut from 30-hrs. to 8 by powder-lancing.

The speed of powder-lancing enables a steel mill to cut labor costs by more than ⅔, and reduce the consumption of lance pipe to less than ½ that ordinarily required.

In powder-lancing, a powdered metal is added to the oxygen lance process which raises its "flame" temperature, and increases the rate of melting or oxidation in the material being lanced.

A powder-lance can pierce holes in many materials that resist a standard oxygen lance. Blast furnace refractory, concrete, cinder blocks, fire brick, aluminum billets, steel and cast iron containing inclusions, and sand and metal incrustations—all yield quickly and easily to powder-lancing.

Powder-lancing is helping to speed production and maintenance in mills throughout the country. LINDE service engineers will be glad to help you determine the latest, most efficient setups for any lance operation. Call your local LINDE representative for more information. Save time and money, call him today.

LINDE AIR PRODUCTS COMPANY
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WHY "SECOND GUESS"... WHEN YOU CAN BE RIGHT AT THE START?

Lubricating oil is a mill's life blood. So any mill lubrication system has to be right . . . the *first time.*

When the system is completely *De Laval*-engineered you know—before a single wheel turns—that it *will* be right . . . in overall design . . . in component parts . . . in every detail down to the smallest pipe-fitting.

Your assurance comes from De Laval's long experience . . . and the reputation acquired in custom-engineering lubrication systems for many of America's most efficient mills.

Whether you are planning a new mill or revamping an old one, be right at the start by putting the entire responsibility for lubrication in De Laval's hands!

DE LAVAL
engineered mill lubrication system

THE DE LAVAL SEPARATOR COMPANY Poughkeepsie, New York • 427 Randolph St., Chicago 6 • 2420 Grant Building, Pittsburgh, Pa.
DE LAVAL PACIFIC CO. 61 Beale St., San Francisco 5

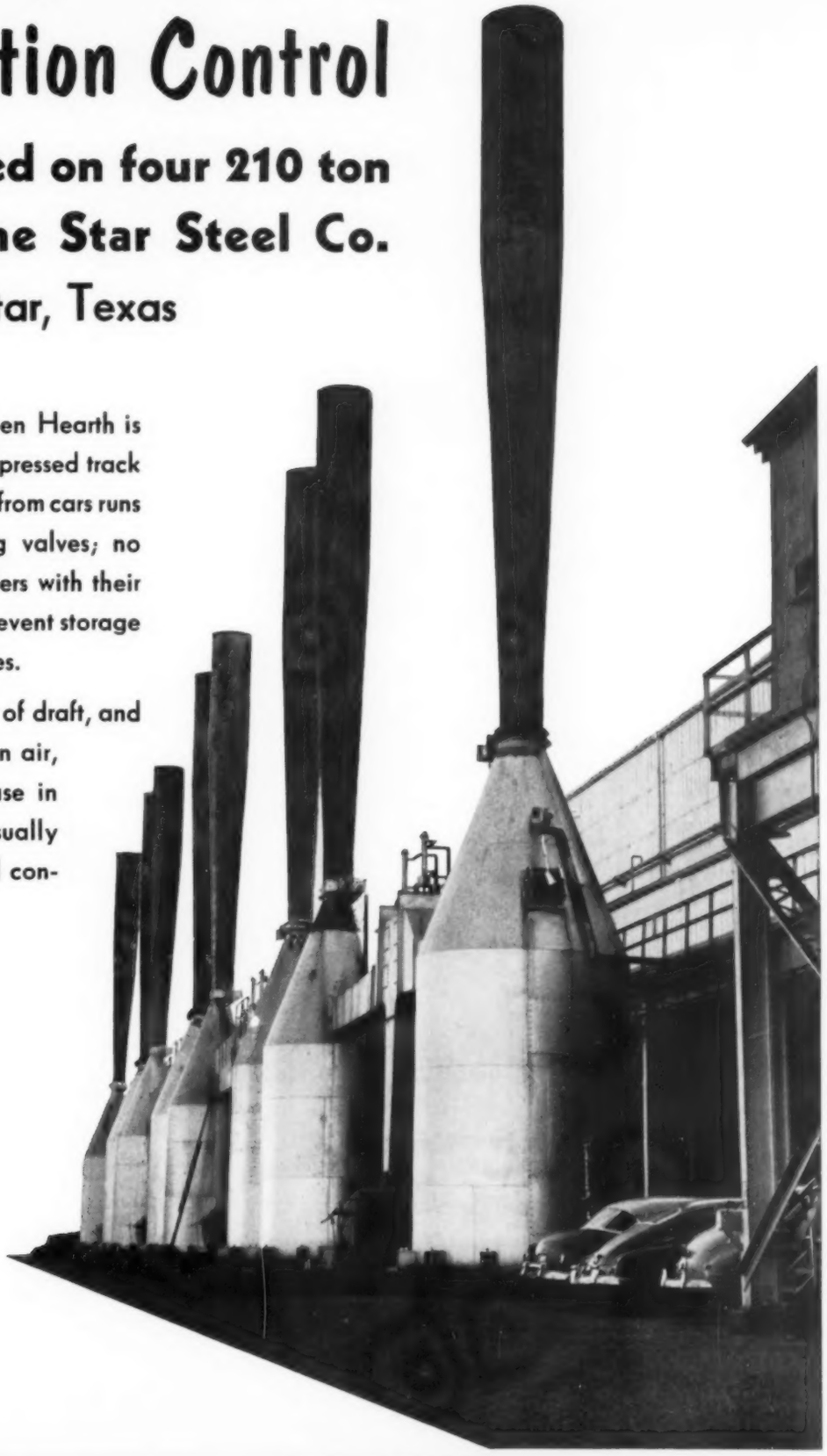
Morgan-Isley Combustion Control

installed on four 210 ton furnaces at Lone Star Steel Co.

Lone Star, Texas

The cellar of the Lone Star Open Hearth is a superintendent's dream. A depressed track to unload palletized refractories from cars runs from end to end. No reversing valves; no fans; no air piping, and no boilers with their auxiliaries to impede traffic or prevent storage of refractory materials and spares.

In addition, the absolute control of draft, and accurate metering of combustion air, with a possible generous increase in air temperature, makes for unusually high tonnage rates and low fuel consumption.



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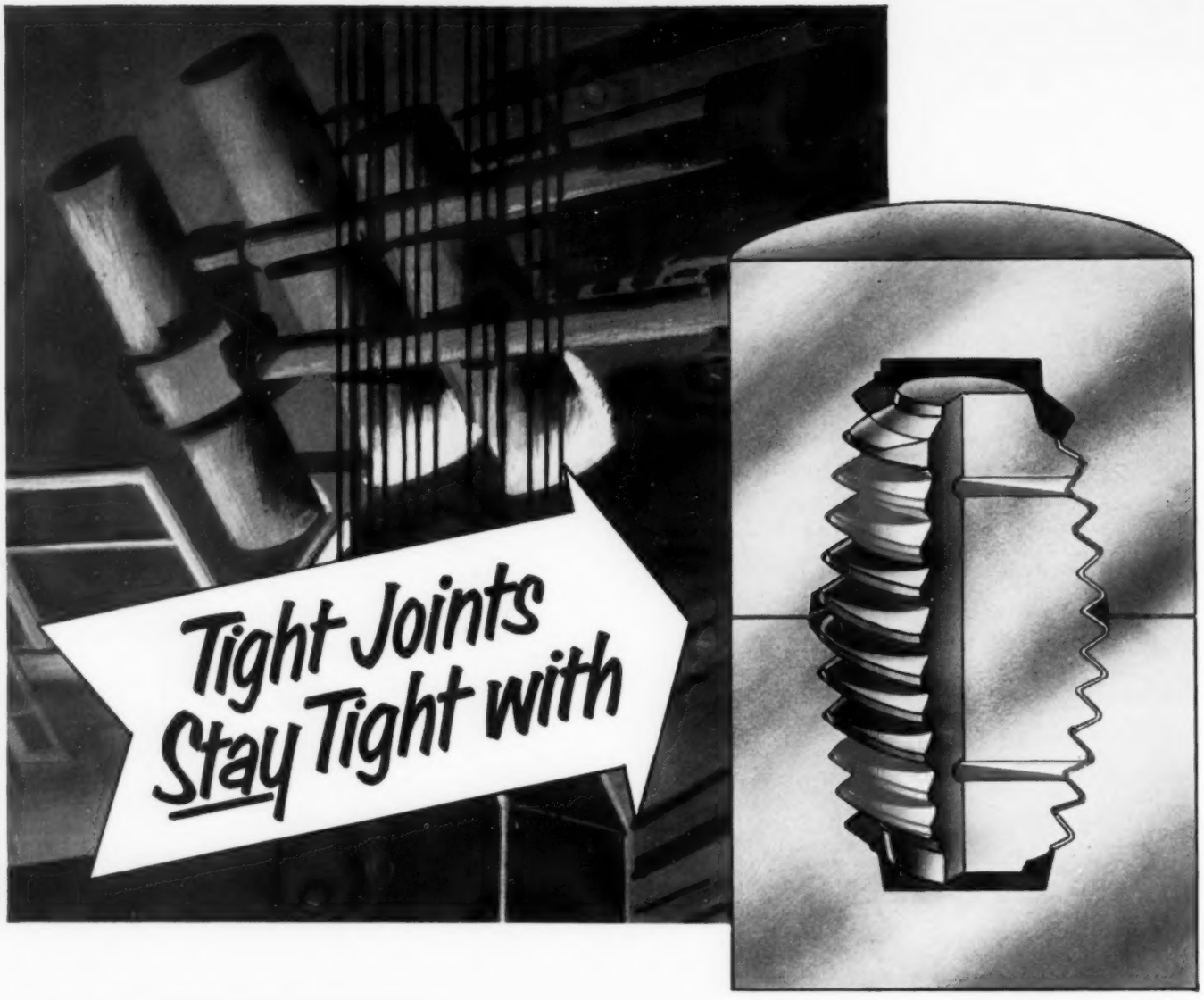
MORGAN CONSTRUCTION COMPANY WORCESTER, MASS.

ROLLING MILLS • MORGOIL BEARINGS • WIRE MILLS • REGENERATIVE FURNACE CONTROL • EJECTORS • GAS PRODUCERS

H. H. Wood, Rep., Koppers Bldg., Pittsburgh, Pa. *English Rep.*, International Construction Co., 56 Kingsway, London W. C. 2, Eng.



NATIONAL PITCH-RESERVOIR NIPPLES*

TRADE-MARK

THE NEW PITCH-RESERVOIR NIPPLE, an exclusive "National" product, is another major contribution by National Carbon Company to more efficient electric furnace operation. You can now be sure that tight joints will stay tight under normal load and service conditions.

"NATIONAL" PITCH-RESERVOIR NIPPLES, designated Type PR-F, are now available for electrode diameters from 14" to 24". Thoroughly proved in service, they are identical in strength, size, shape, tolerances, composition and quality to our standard, tapered, graphite nipples. Talk it over soon with your National Carbon Company electrode representative.

***PATENTS PENDING**
EXCLUSIVE DESIGN

HERE'S HOW IT WORKS:

Reservoirs near each end of the nipple contain pitch. As the electrode column becomes hot in service, the pitch flows from the reservoirs into the threaded sections of the joint and cokes out, cementing and locking the threads of the nipple and sockets together.

FOR ELECTRODES AND ELECTRODE SERVICE...
Rely on NATIONAL CARBON COMPANY!

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A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto

Personnel News...

H. W. Seyler, general superintendent of Clairton Works, has been appointed assistant vice president—coal chemical operations, United States Steel Corp. In this newly-created position Mr. Seyler will coordinate the operations of all of the corporation's coal chemical plants. He has been general superintendent of Clairton Works for the last 11 years and has had a total of 36 years' experience in coke and coal chemical plant operations.

David P. Finney was appointed general superintendent of Clairton Works, United States Steel Corp., succeeding **H. W. Seyler.** At the same time, **Frederick A. Dudderar** was named assistant general superintendent. Mr. Finney was first employed by United States Steel in 1908 in the open hearth department of Clairton Works. In 1918 he was transferred to the coke and coal chemicals division as turn foreman and after several promotions was made assistant division superintendent of coke and coal chemicals in 1937. He was made division superintendent in 1939. He advanced to assistant general superintendent of Clairton Works in 1944, the position he held at the time of his present appointment. Mr. Dudderar started at the Clairton plant in 1940. In 1941, he went to the general offices, Pittsburgh, industrial engineering department. From 1942 to 1944 he was employed at Homestead District Works, advancing to assistant to the plant industrial engineer. He returned to Clairton in 1944 as assistant plant industrial engineer and later the same year became assistant to the division superintendent, coke and coal chemicals division. In March, 1951, he was appointed division superintendent, the position he held prior to his new appointment.

Calvin H. Windle has been named superintendent of the cold strip department of Republic Steel Corp.'s Warren district steel plants. Mr. Windle, formerly assistant superintendent of the mechanical department, succeeds **J. W. McMahon,** cold mill superintendent since 1928, whose duties are being lightened. At the same time, **Louis Hollis** was named assistant superintendent of the cold mills. Mr. Windle joined Republic Steel in 1933 as a millwright helper in the hot strip mill department. In 1938 he became cold strip mechanical foreman and in 1948 was named assistant mechanical superintendent. Mr. Hollis worked for the West Leechburg Steel Co. before coming to Republic as a roller in the cold strip department in 1931. He was made a turn foreman in 1936 and served in every supervisory capacity in the cold strip department until 1952 when he was made general foreman. He was named acting superintendent last August.

Harry O. Zimmerman is the new manager of Inland Steel Co. coal properties. He was formerly assistant to the manager and succeeds **John T. Parker,** who died January 12.

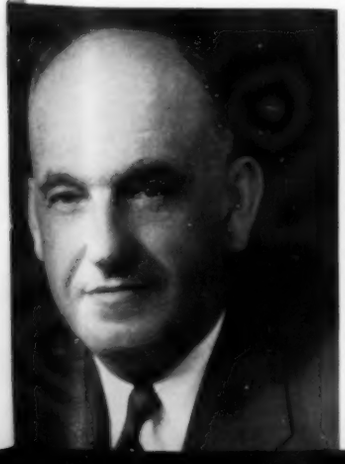
W. J. McBride, formerly general foreman, has been appointed assistant superintendent, rolling mills, Green River Steel Corp.

Fred S. Ebinger has been named assistant superintendent of the mechanical department at Republic Steel Corp.'s Warren district plant, and **William J. Shand** has been appointed assistant superintendent of the hot strip finishing department. Mr. Ebinger succeeds **Calvin H. Windle,** recently named cold strip superintendent. Mr. Shand succeeds **R. C. Boles,** who is being assigned other duties in the department.

Gerald M. Hatch was appointed chief engineer for Republic Steel Corp.'s Union Drawn Steel Division. He succeeds **Walter L. Brough,** who has resigned. Mr. Hatch will supervise engineering activity at Union Drawn plants in Massillon, Ohio, Beaver Falls, Pa., East Hartford, Conn., Gary, Ind., Los Angeles, Calif. and at a Republic subsidiary in Hamilton, Ontario, Union Drawn Steel Co., Ltd.

G. E. Brock, acting staff engineer—rolling mills in the office of the chief engineer of Jones & Laughlin Steel Corp., has been named resident engineer at J&L's Aliquippa Works Division. He succeeds **E. H. Wilson,** who, following his retirement has been appointed consultant to the resident engineer at Aliquippa. **D. L.**

H. W. SEYLER



DAVID P. FINNEY

LOUIS HOLLIS

HARRY O. ZIMMERMAN

DONALD F. PEASE

DAVID K. TOMER

HARRY COTESWORTH

KURT R. WEISE

Calhoun, acting assistant resident engineer, at Aliquippa, was named assistant resident engineer at the works. Mr. Brock started with J&L in 1930 and has worked in various departments of the corporation, including the blooming mill, by-product, industrial engineering, seamless tube, and design engineering. He was named assistant resident engineer, Aliquippa, in 1951 and was transferred to the office of the chief engineer as acting staff engineer—rolling mills, in 1954. Mr. Wilson joined J&L in 1942 as assistant resident engineer after holding positions as vice president, Taylor-Wilson Manufacturing Co., sales engineer, Aetna-Standard Engineering Co., and owner and operator of a consulting engineering firm. Mr. Calhoun has been in steel plant engineering for 25 years. He joined J&L in 1949 as a supervising engineer and on July 1, 1952, he was named staff engineer—rolling mills. In 1954 he was named acting resident engineer at Aliquippa Works. Prior to joining J&L, Mr. Calhoun was vice president of H. W. North Co.

Donald F. Pease was appointed assistant vice president of industrial relations, United States Steel Corp. In this newly created position Mr. Pease will be responsible for general plans and special projects for industrial relations.

David K. Tomer has been appointed administrative assistant to the president of Blaw-Knox Co. Mr. Tomer joined the company in 1953 as manager of the control section.

Harry Cotesworth has been advanced to chief engineer of the development department, Cleveland Crane & Engineering Co., and **Kurt R. Weise** will hold the position of chief engineer of the Cleveland tramrail division.

Laurence W. Hayward, former assistant chief engineer of the Babcock & Wilcox Co.'s Boiler Division, has been named manager of the newly-formed contract and erection department. **R. W. Fox,** contract manager, and **J. P. Craven,** erection superintendent, will continue to be in charge of these respective functions, under Mr. Hayward.

John J. Dixon has succeeded **Frank H. Schwerin** as chief engineer of Duff-Norton Manufacturing Co. Mr. Dixon joined Duff-Norton in 1943 after serving in the engineering department of the Edwin L. Wiegand Co. Mr. Schwerin is retiring after 36 years with Duff-Norton.

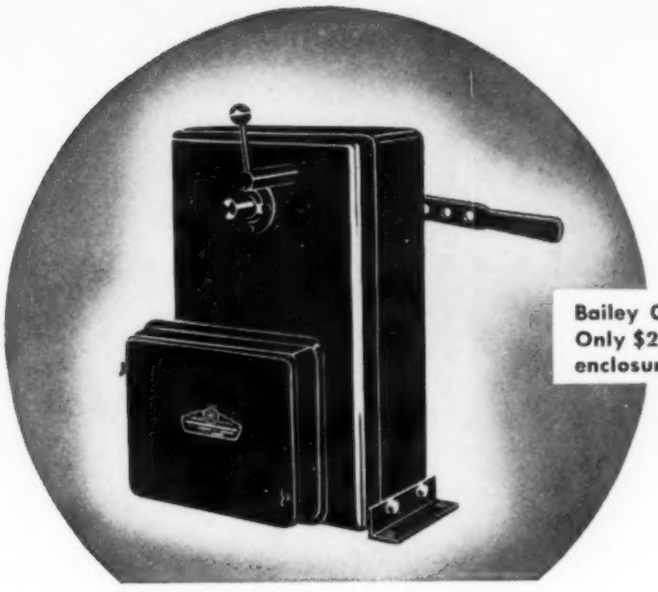
John W. Bodwell has been appointed manager of the work order division, Joseph T. Ryerson & Son, Inc. He succeeds **William G. Findlay** who has assumed the position of assistant manager of the Ryerson plant in Detroit. Named to succeed Mr. Bodwell as manager of the work order department, Chicago plant, is **Harold W. Davidson.**

Arnold Challman, for the past four years manager of Minneapolis-Honeywell Regulator Co.'s branch office in Peoria, Ill., has been named to the newly created position of administrative assistant to the manager in the company's regional sales and service office in Chicago. **R. C. Ferguson,** formerly manager of the company's district sales office in Davenport, Ia., will manage the Peoria branch office while **R. R. Scott,** former regional sales manager for the valve division in Chicago, is the new manager of the Davenport office.

John G. Buechel has been appointed general sales manager of Durabla Manufacturing Co. In his new capacity, Mr. Buechel will head up sales of sheet packing, gaskets, pump valves and check valves. Since 1950, Mr. Buechel has held the position of eastern district sales manager with offices in New York City.

Dewey O. Olson was appointed mill works manager of the Follansbee Steel Corp. plant at Follansbee, W. Va. Mr. Olson has for the past sixteen years served as general superintendent of the Michigan Steel Division of the Great Lakes Steel Corp.

James A. Wilson has been appointed plant manager of Kaiser Aluminum & Chemical Corp.'s Baton Rouge, La., alumina plant. **Ray Woodman,** who has been manager of operations at Baton Rouge during the plant expansion program this past year, will return to the corporation's Oakland, Calif., headquarters to assume duties as manager of the raw materials division.



Bailey Control Drive, Type AC44P Model 200. Only $210.00 F.O.B. Cleveland, complete with enclosure, positioning relay and hand operator.

Want Better Flow Characteristics from Your Regulating Devices?

This new, small, piston-operated Bailey Control Drive will improve the flow characteristics of butterfly valves, dampers, hydraulic couplings, feeders and similar regulating devices. Adjustment is simple; any desired relation between drive motion and pneumatic signal may be secured.

You can install this compact pneumatic drive power unit in any position on a column, pipe, or flat surface—and connect it to the regulating device with standard Bailey linkage, available from stock.

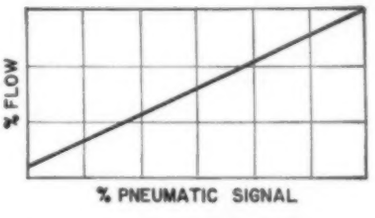
Speed (time required for full travel) is adjustable to suit your requirements. Bailey Control Drives operate on standard SAMA pneumatic signal ranges of 3 - 15 or 3 - 27 psig.

AVAILABLE FROM STOCK in 3 standard sizes

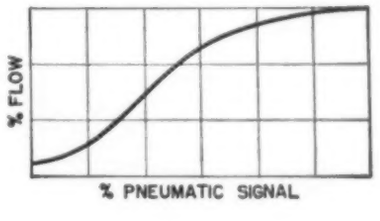
Type	Piston Dia. Inches	Piston Stroke Inches	Torque ft-lb	Max. Travel Degrees	Approx. Dimensions Inches
AC816	8	16	1500	90	13 x 27 x 51
AC68	6	8	400	90	13 x 19 x 34
AC44	4	4	75	75	10 x 11 x 19

P-28

The New Bailey Control Drive gives you THIS—



instead of THIS



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CLEVELAND 10, OHIO

Complete Controls for Process Plants

BAILEY METERS

Controls for

TEMPERATURE
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FLOW . LEVEL
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☐ I am interested in Bailey Control Drives. Mail me Spec. CA040.

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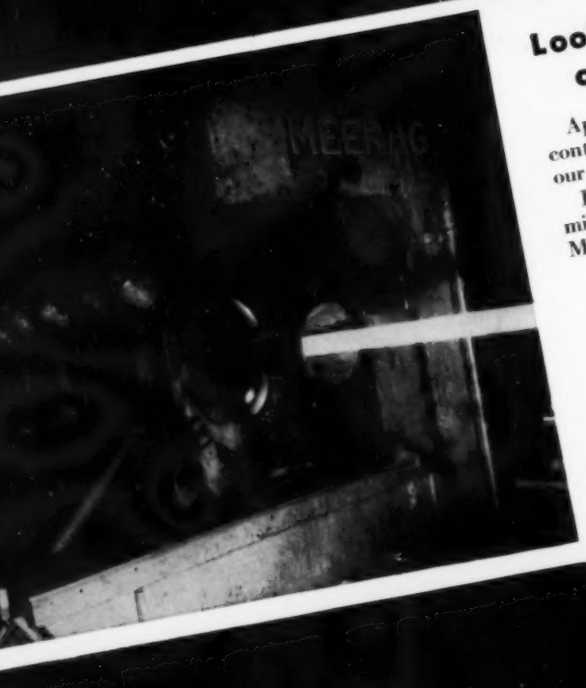
Newest idea in seamless tube production



Looking for improved methods of tube and pipe making?

Applying the three-roll arrangement for high speed continuous tube and pipe rolling mills is only one of our recent firsts in mill design.

Bringing new developments to bear on your tube mill problems is second nature for Mannesmann-Meer. Nowhere else is the combination of

- **CREATIVE ENGINEERING**
- **DESIGN EXPERIENCE**
- **OPERATING BACKGROUND**
- **AMERICAN MANUFACTURING SKILL**

available and ready to go to work for you. Call on Mannesmann-Meer Engineering & Construction Company, 900 Line Street, Easton, Penna. M-14

MANNESMANN-MEER

World Specialists in High-Speed Tube Mill Machinery

H. W. Cory was promoted from assistant chief engineer to chief engineer of Allis-Chalmers Manufacturing Co., control engineering. He succeeds **T. B. Montgomery.**

Fred B. Riggan former vice president in charge of research and development for the Key Co., and consultant to the steel foundry industry, has joined Texas Steel Co.

E. L. Elliott was appointed chief engineer of the Alliance Machine Co. Mr. Elliott has been design

E. L. ELLIOTT

engineer in charge of new equipment for the Alliance firm for over 25 years. **F. K. Tanner** is assistant chief engineer in charge of inspection.

John H. Faunce, Jr., became director of market and commercial development at Lukens Steel Co. In his new position, Mr. Faunce, former manager of market development, becomes a member of the company's management committee.

John H. Mulcahy was named superintendent of industrial relations at Republic Steel Corp.'s Youngstown District steel plant. He succeeds **Frank A. Lauerman,** who is retiring after heading the department since 1948.

John J. Murray and **Richard Doughton, Jr.,** have been appointed development engineers in the Product Development Division of Jones & Laughlin Steel Corp. Mr. Murray had been supervising engineer in the design engineering department of J&L's Pittsburgh Works since 1948. Mr. Doughton was staff metallurgist for the Materials Advisory Board of the National Academy of Sciences, Washington, D. C.

Russell R. Clark and **Charles F. Persch** have been appointed assistant general traffic managers of Republic Steel Corp.

Edward G. Kreyling, Jr. has been named director of market research at Laclede-Christy Co., Division of H. K. Porter Co., Inc. Mr. Kreyling will be responsible for market research involving products, markets, distribution and pricing of all refractory products and vitrified products.

Frank M. Cashin, manager of the Chemicals Division, has been appointed a vice president of Kaiser Aluminum & Chemical Corp.

FRANK M. CASHIN

Elmer M. Pearson has been appointed superintendent of steel conservation and quality control at Republic Steel Corp.'s Chicago district steel plant. Mr. Pearson joined Republic in 1921, and has been assistant superintendent of quality control since 1948.

A. R. Gaus was elected a vice president of Erie Forge & Steel Corp. Before joining Erie Mr. Gaus was vice president of the Midvale Co., having been with that concern over twenty years.

Willis I. McCord has been made manager of electronic sales by Diamond Power Specialty Corp.

WILLIS I. McCORD

C. R. Grange, formerly assistant district manager of Air Reduction Sales Co. at Dayton, Ohio, succeeds **L. O. Geiger,** who is retiring after 38 years service.

John M. Gehr has been appointed assistant to works manager—personnel relations at the Aliquippa Works

of Jones & Laughlin Steel Corp. He succeeds **R. A. Dye** who has been named administrative assistant to the director—personnel relations in J&L's general office.

Dr. Kurt C. Frisch was appointed assistant manager of research of E. F. Houghton Co. He has been supervisor of organic research in the Houghton laboratories since 1952.

B. G. Witty will head a newly-formed industry application section of Allis-Chalmers Manufacturing Co. **T. B. Montgomery** was named chief engineer of the section. Mr. Witty has been manager of the company's St. Louis district since 1950. He is succeeded at St. Louis by **W. E. Korsan,** a representative in that office since 1945. Mr. Montgomery has been chief engineer of Allis-Chalmers control engineering section since 1953.

James W. Tysse has been appointed manager of safety for Republic Steel Corp. He was formerly safety supervisor for Republic's Chicago district. He succeeds **Walter M. Nelson,** who recently was named an assistant director of industrial relations for Republic.

D. T. Bixby was named sales manager of standard products division of De Laval Steam Turbine Co. Prior to his new post, Mr. Bixby served as sales manager of the company's Seattle district office.

John D. Russell, formerly manager of engineering, Joy Manufacturing Co., has been appointed vice president, engineering, of the company, with headquarters at Joy's executive offices in Pittsburgh, Pa.

Tom Stanton was named assistant sales manager of Basic Refractories, Inc. for the eastern district, covering the Pittsburgh, Wheeling, Weirton, Philadelphia and northeastern area. Before joining the company in 1945 as a sales and service engineer, he was associated for ten years with Youngstown Sheet and Tube Co., where he rose in the open hearth and electric furnace departments to first helper and melter. Also announced is the appointment of **George J. Peer** to the sales staff of Basic Refractories. Before joining the company Mr. Peer was associated with Republic's Canton, Ohio alloy plant where he served in Technical operating capacities, and as assistant foreman. He will assume his new sales and service duties in the Chicago district office.

D. G. Gibson succeeds the late **Harry Trump** as district manager of the Timken Roller Bearing Co.'s Dallas territory.

Paul E. Shroads was elected senior vice president of National Steel Corp. Prior to his advancement, Mr. Shroads occupied the positions of vice president and treasurer and will continue to exercise the latter function.

Arch Miller has been named manager of the tin mill at Weirton Steel Co., succeeding **Glenn W. Gould** who was appointed assistant general superintendent. **George E. Hugus** has been named assistant manager to succeed Mr. Miller.

Donald H. Dodt was named Cleveland district manager of the Electric Controller & Manufacturing Co.

Charles LeB. Homer has been appointed president of the Stran-Steel Division of Great Lakes Steel Corp., and **J. E. Bowen,** who has been associated with the Stran-Steel Division for many years, has been appointed vice president in charge of sales.

Robert P. Hartzell has been appointed sales manager of Alliance Machine Co. He has been supervisor

ROBERT P. HARTZELL

of erection in the field for the company since 1939. **Edward L. Cox** has been made office manager for the sales department.

Norman N. Breyer, formerly chief of the Armor Section, Detroit Arsenal, has joined Continental Foundry & Machine Co. as metallurgist for the Armor Division.

James L. Duchene was named sales engineer for iron and bronze foundry products in western Pa., northern W. Va., and southern Ohio. Prior to joining Baldwin, Mr. Duchene was sales representative for National Bearing Division, American Brake Shoe Co.

Robert Neilson has been appointed engineering specialist in metal forming and drawing of Baldwin-Lima-Hamilton Corp. Mr. Neilson will serve as consultant on problems involving capacity and tool selection as required in hydraulic press application. Prior to joining Baldwin, Mr. Neilson was chief tool engineer, for the Scaife Co.

Charles E. Mainprice is the new Calif. representative for the Ironton Fire Brick Co.

C. Dana McCoy has been named New York manager and International director of the Rust Engineering Co. Prior to joining the Rust organization, Mr. McCoy was director, international division, of the Foster Wheeler Corp.

STRAIGHT FACTS ABOUT STRAIGHT TUBING

from MACK-HEMP'S ROTARY STRAIGHTENER CASE HISTORY FILE

HARD BRASS TUBING STRAIGHTENED 250 FT. PER MINUTE; "SKIN HARDENING" ON COPPER TUBING ACCOMPLISHED

with Model AXY Rotary Straightener

Straightening brass tubing at speeds up to 250 ft. a minute, the Model AXY Rotary Straightener meets exacting straightness specifications at The National Copper & Smelting Company, Cleveland. Skin hardening of soft copper tubing, not possible prior to installation of the straightener, now protects the tubing against accidental damage to straightness and roundness during handling, yet permits easy bending during fabrication.

The Model AXY straightens hard brass tube in diameters of from ⅜ to ⅞ in. and copper tube from ¼ to 1⅛ in. diameters. Wall thicknesses of the 12 to 20 ft. lengths vary from .020 to .125 in.

PRODUCTION UP 13 TIMES— 7,500 FT. OF TUBING STRAIGHTENED PER DAY

with a Model AY Rotary Straightener

Straightening of these stainless steel tubes was expedited with the installation of this Model AY Rotary Straightener at Bell Aircraft's Niagara Falls Plant. Bell had been straightening 300 pieces of 23 in. long tubing per day. Now, up to 7,500 ft. of tubing per day is straightened. Absence of guides and design of its six straightening rolls assure perfect product finish.

Each Bell rocket engine for guided missiles uses tubes made from fully annealed stainless steel No. 304. This tubing has a ⅜ in. O.D., a .028 in. wall, and a tensile strength of 75,000 psi.

There's a MACK-HEMP Guideless Rotary Straightener to remove "bows," "bends" and "hooks" from all types of metal tubing — from .050 in. fine instrument tubing to 15 in. welded steel pipe —with high speed, low cost, consistent accuracy and superior surface quality.

Perhaps our large case-history files of successful solutions hold the answer to your tough tube straightening problems. Write for our new Bulletin No. 55 for more detailed information.

MACKINTOSH HEMPHILL COMPANY PITTSBURGH U.S.A.

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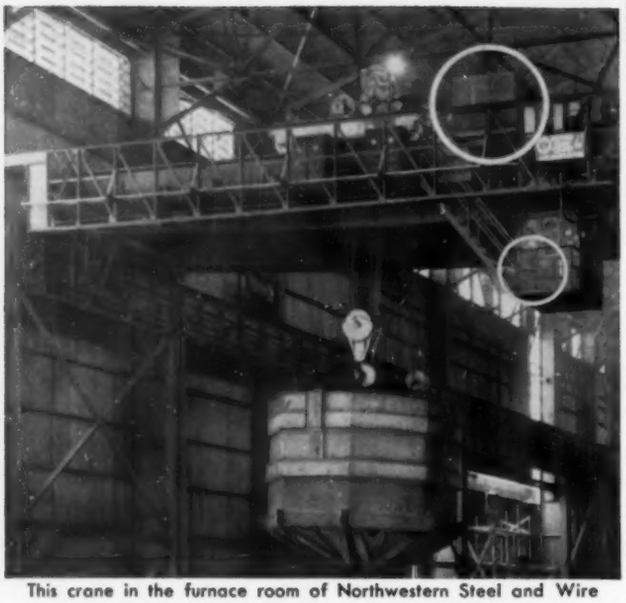
COMPANY

Makers of the rolls with the striped red wabblers

PITTSBURGH AND MIDLAND, PA.

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: all types of cast mill rolls . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . Mackintosh-Hemphill rotary straighteners . . . electronically controlled contouring lathes . . . shears . . . end-thrust bearings . . . steel and special alloy castings . . . reversing hot strip mills . . . Y-type cold strip mills.



This crane in the furnace room of Northwestern Steel and Wire Company's new West Mill at Sterling, Illinois, was installed by the Bedford Foundry and Machine Company. Its cab is air conditioned with an Aire-Rectifier—one of many Lintern air conditioning units purchased by this company over the past several years.

how AIRE-RECTIFIERS help keep costs down...

Even when mills run at normal production, it is equally important, as at low production, to keep costs down, yet obtain maximum output from cranes and crane operators.

Lintern Aire-Rectifiers provide: increased production due to men working under normal, healthful conditions; improved personnel relations; reduction of wild cat work stoppages; elimination of relief men and premium rates. These savings soon equal the capital investment for an Aire-Rectifier.

Many exclusive features make Lintern Aire-Rectifiers the choice of practically every steel and industrial plant using air conditioning on crane cabs and pulpits — features which assure unequalled cooling and filtering of the air at the lowest possible cost — features which have proven their worth in hundreds of applications while keeping maintenance costs at a minimum.

Ask for new Bulletin AC-549.

Also Bulletin P-552 on Pulpit Air Conditioning

THE LINTERN CORPORATION

ROUTE 20, EAST • PAINESVILLE, OHIO

Earl R. Miller has been appointed plant engineering manager at Electric Storage Battery Co.'s Crescentville plant, succeeding **Wilbur W. Ferris. A. H. Shaw** was named plant development engineer, and **Robert L. Chalfant** has been appointed a plant engineer.

William F. Fetzer has been named general sales manager of the Phillips Corp.

Obituaries

John Theodore Parker, 53, manager of Inland Steel Co. coal properties at Wheelwright, Ky., died January 12. Mr. Parker was first employed by Inland in 1926 as a mining engineer at Indianola, Pa., but was transferred four years later to its operations at Wheelwright, where he was successively mine engineer, mine superintendent and general superintendent before becoming manager just one year ago.

Jerald P. Moore, Cleveland district manager of the Electric Controller & Manufacturing Co., died January 13, at the age of 61. Mr. Moore, a member of the AISE, joined the company in 1923.

William B. Hackett, 65, of the Lewis Machinery Division, Blaw-Knox Co., died December 24. He had planned to retire January 1. A member of the AISE, Mr. Hackett joined Lewis in 1937 as chief engineer. He subsequently became vice president in charge of engineering, and at the time of his death was consultant to the vice president and works manager of engineering and sales.

SO-O MUCH SIMPLER!

SOLID STEEL CONVEYOR PULLEYS

STEEL HUBS with famous Taper-Lock bushing (patented) give equivalent of shrunk-on fit. No "walking" on shaft. Easy on — easy off. Drum type construction provides maximum strength with minimum weight. Diameters 6 in. to 8 ft., all face widths. Popular sizes stocked by Dodge Distributors. Write us for complete data on the extensive range of Dodge Steel Conveyor Pulleys.

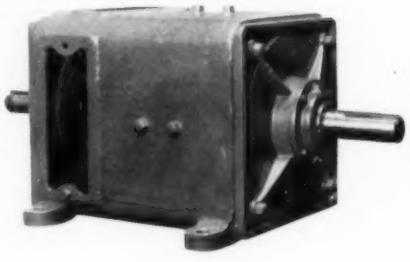
DODGE MANUFACTURING CORPORATION, 5900 Union St., Mishawaka, Ind.

DODGE

of Mishawaka, Ind.

FIRST IN POWER TRANSMISSION MACHINERY

Hundreds of Conversions by Bearings, Inc.

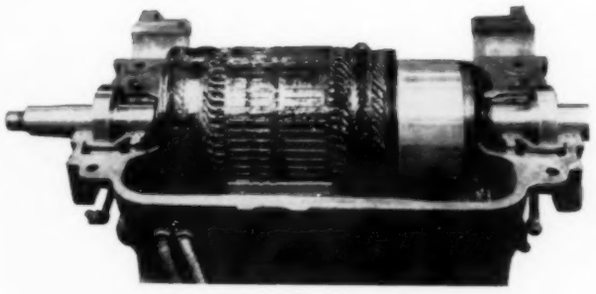


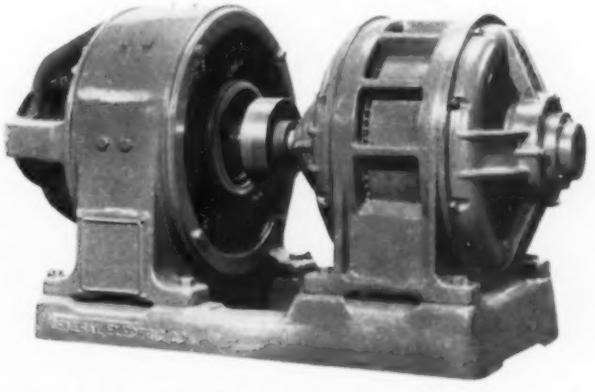
Prove the Value of Keystone Ball & Roller Bearing End Bells for

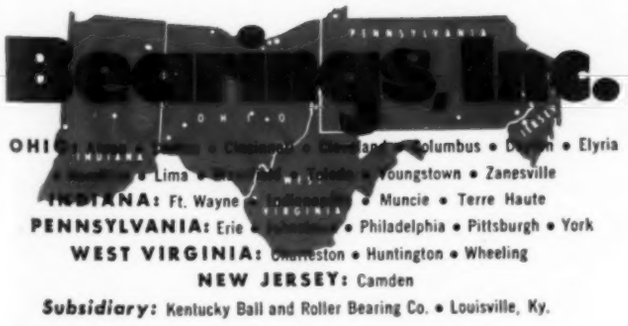
GENERAL PURPOSE, CRANE & MILL MOTORS

Conversion of sleeve bearing motors to Keystone Ball or Roller Bearing End Bells has often meant really spectacular results in lower motor maintenance cost! Eliminating most armature changes and rewinding expense has often paid the cost of the conversion within a short time... And once installed, your Keystone Conversion requires no maintenance beyond a lubrication check once a year. Every Keystone bearing housing is permanently sealed against dirt and dust.

Hundreds of designs of all makes and sizes of general purpose, crane and mill motors are available for Keystone Conversions with little or no machining. Bearings, Inc. engineers will be glad to show you how the installation of Keystone Units can banish repetitive maintenance costs and at the same time give increased efficiency to your overall operation.







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I would like to receive a Keystone Application Manual.

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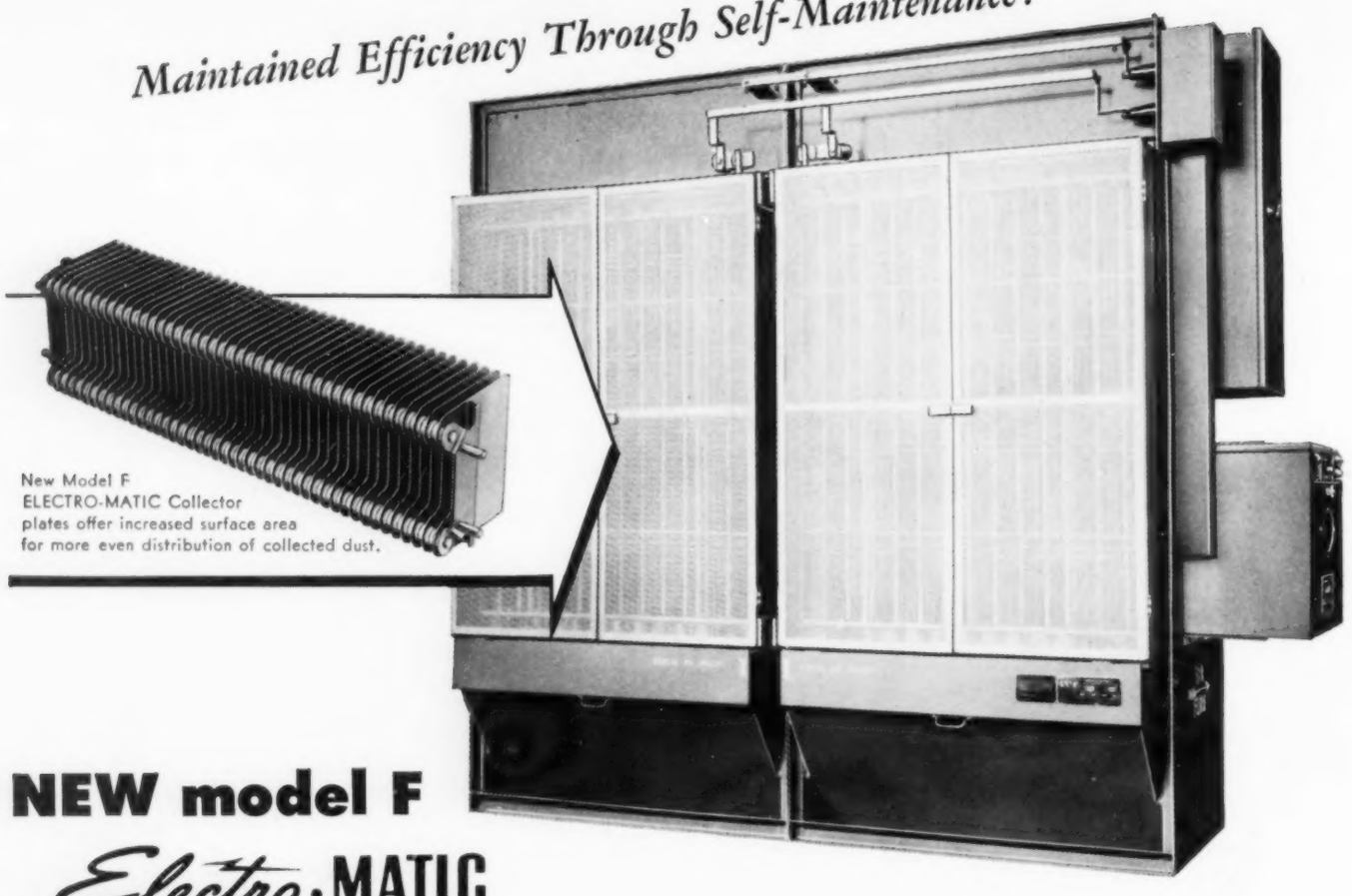
Maintained Efficiency Through Self-Maintenance!



New Model F
ELECTRO-MATIC Collector
plates offer increased surface area
for more even distribution of collected dust.

NEW model F Electro·MATIC

Delivers Uniformly Clean Air, Continuously, Around the Clock

WANT a continuity of clean air that won't vary in quality from one day, month or year to another? It's yours with the Model F ELECTRO-MATIC—the new electronic precipitator whose continuous high efficiency is assured through constant self-cleaning.

The cleaning efficiency of the Model F ELECTRO-MATIC extends over a wide range of particle sizes, from smoke to largest air-borne materials. Its "capacity for work" is increased, too. Newly designed collector plates increase surface area 53% to further reduce possibility of dust build-up and, at the same time, slows down air velocity between plates by 25%.

But here's the payoff! Unlike most other filters, ELECTRO-MATIC's efficiency can't taper off due to the accumulation of dust. Continuous self-cleaning action keeps collector plates in constant fighting trim. There's no time out for washing down with hot water. No need for extra sewer or water connections. ELECTRO-MATIC maintains its own rigid housekeeping schedule without regard to clock or calendar.

Yes, if performance is the payoff, the Model F ELECTRO-MATIC is definitely today's finest electronic filter. For complete product information, call your local American Air Filter representative, or write for Bulletin 250.

AAF herman nelson

American Air Filter
COMPANY, INC.

American Air Filter of Canada, Ltd., Montreal, P. Q. • 302 Central Avenue, Louisville 8, Kentucky

the first helper's first helper at INLAND STEEL

ASKANIA OPEN HEARTH CONTROLS

In the new open hearth shop at Inland Steel Company's Indiana Harbor works, this panel houses one of four complete Askania control systems.

No control replaces the skill and judgment of an experienced open hearth operator. But an Askania installation adds to his skill by putting accurate and dependable control at the tips of his fingers. It is truly the first helper's first helper.

This is modern open hearth control—completely automatic but flexible. In the hands of your operators, it is a tool that helps them make more steel and better steel for less money. Furnace pressure is controlled to a hairsbreadth. Air flow and fuel flow are precisely proportioned to each other. Flow of atomizing steam to the burners is closely regulated to the operator's setting. Automatic reversal cuts fuel-off time to a few seconds, uses checker heat most effectively. A complete record of all that happens lets the operator duplicate his results in heat after heat.

Steel men rely on Askania Controls—common-sense controls that make their job easier and the results better. Askania equipment is simple and sturdy—designed and built to do the hardest jobs for the longest time.

Write for Bulletin 115, Askania Open Hearth Furnace Control.

ASKANIA REGULATOR COMPANY
246 E. Ontario Street, Chicago 11, Illinois
Subsidary of General Precision Equipment Corp.

VICTOR R. BROWNING
MILL TYPE CRANES

to Specification..

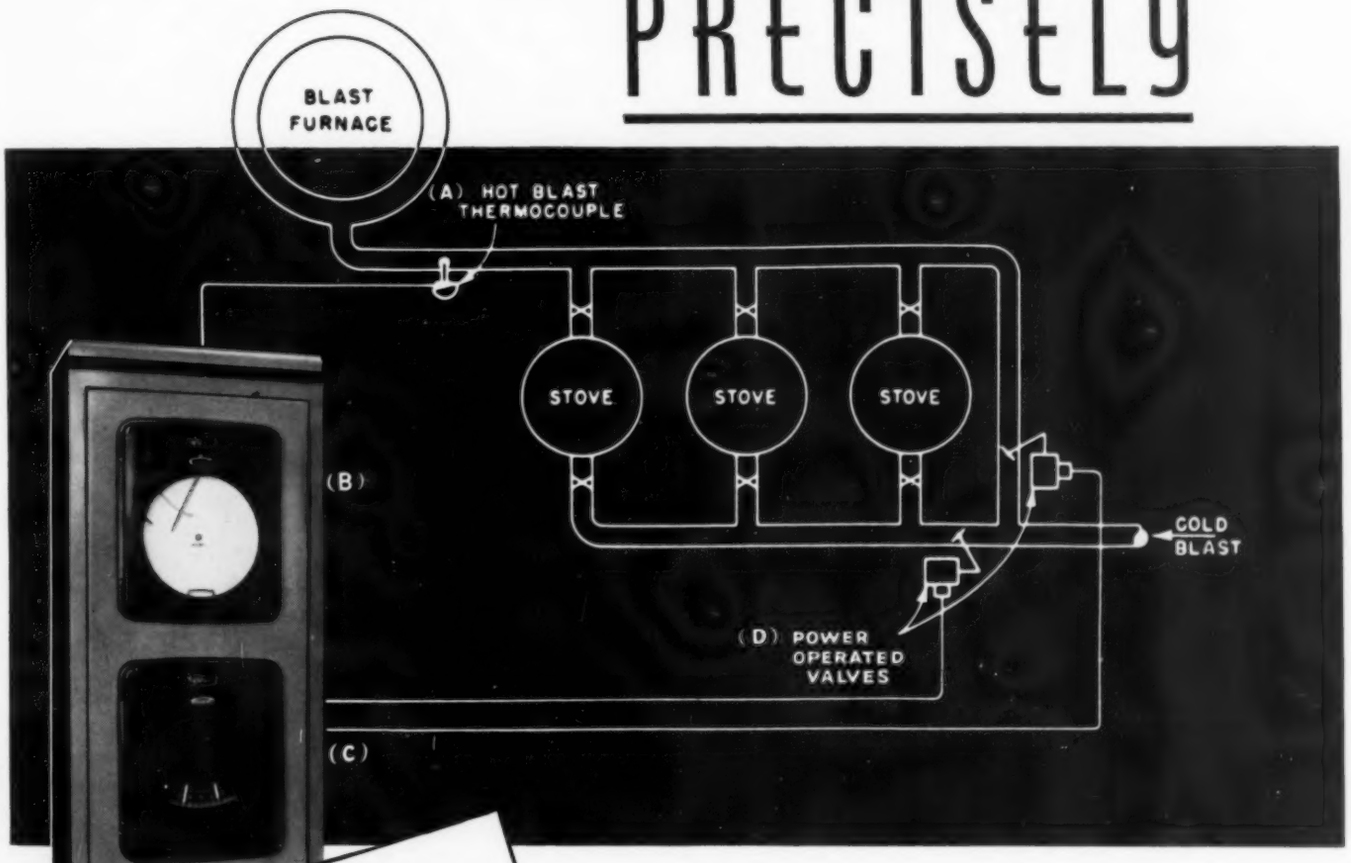
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.
WILLOUGHBY (CLEVELAND), OHIO
DESIGNERS AND BUILDERS OF ELECTRIC OVERHEAD TRAVELING CRANES AND HOISTS AND ELECTRIC REVOLVING CRANES

Up your Furnace Tonnage...

by controlling Hot Blast Temperature

PRECISELY



HERE'S HOW IT WORKS

Hot blast temperature is sensed by thermocouple (A) and recorded by the Foxboro Dynalog Temperature Controller (B). This controller continuously adjusts the set point of the Foxboro Duplex Controller (C), which positions the power-operated butterfly valves (D) in proper relation to mix hot and cold air automatically — thus maintaining the desired blast temperature. This Duplex Control System permits convenient adjustment of valve sequencing at the control panel at any time.

Efficient, uniform blast furnace operation, stable fusion zone, and better silicon control all require accurate control of hot blast temperatures. Foxboro Hot Blast Temperature Control automatically accomplishes this with the simplest, most dependable equipment available.

Moreover, this control system also promotes more efficient stove operation . . . provides smoother and faster establishment of correct temperature after change of stoves, and longer refractory life due to more uniform operation.

Why not put this Foxboro Control to work for you now . . . increase your tonnage, improve product quality, and operate stoves more economically. Write for Engineering Data Sheet AED 330-9. The Foxboro Company, 582 Neponset Ave., Foxboro, Mass., U.S.A.

FOXBORO
REG. U. S. PAT. OFF.

Hot Blast Temperature Control

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

COULD YOU LEARN TO CARE ABOUT...

power factor?

"Mortimer Magnetizer is my name. Nobody has ever actually seen me, but anywhere electric motors are being used I get a powerful lot of work done!

"What I do is really simple—I set up the magnetic fields in the motors, and until I get going nothing much happens in your plant.

"Now, that's all well and good. I like my work. But it's the *Power Factor* business that bothers me. Because of *low* power factor in many plants, I get a lot of blame that's really not my fault. Honestly.

"You see, many plants use a goodly number of induction motors, and I like to magnetize them . . . they're hard workers. But unfortunately the reactive kva which I must have to magnetize is not produced by an induction motor. Instead, I must draw it from the main power system, and in a plant full of induction motors I can really 'overdraw' my account!

"This means the incoming power system must carry *two* things—*kilowatts* for useful work by the motors, and plenty of *reactive kva* for my magnetizing. The more of the latter, the less of the former, and brother, that's *low* power factor. It's expensive, because the 'deadhead' reactive kva can't do the work you want done, and yet you pay for it.

"I'm Mortimer Magnetizer. I care!"

"What's the answer? Why, it's simple. The answer is Synchronous Motors. Use them wherever possible! They not only supply their own reactive kva for my magnetizing, but they can even be designed to supply extra or 'leading' reactive kva to offset kva demands elsewhere on the line.

"Now here's Utopia for me! When you use Synchronous Motors to supply reactive kva, you can reach a glorious state called UNITY, in which no costly reactive kva is required from the power system. Brother, that's *high* power factor, and that's how I work best!

"Where to go for Synchronous Motors and expert help on their applications? Go to E-M, of course. E-M pioneered the use of Synchronous Motors . . . E-M engineers know them and their applications from A to Z. And, naturally, Power Factor Improvement is a specialty at E-M.

"Ask any E-M sales engineer near you. He's got facts, data, and helpful suggestions. He knows me, I know him. We work well together!"

THIS New book WILL HELP YOU

"I've just looked over this new special issue of the E-M Synchronizer. It's called 'The ABC of Synchronous Motors' and it's exactly what you need to know to begin improvement of your plant power factor. Save some money . . . improve your efficiency of operation . . . write us on your letterhead, for a copy of 'The ABC of Synchronous Motors' today!"

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

200-TPA-2142

***Specialists in making motors do* EXACTLY WHAT YOU WANT THEM TO**

Publication Service...

FEBRUARY, 1955

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... any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Pocket Data Booklet

A revised edition of Mesta Machine Co.'s handy pocket booklet, "Useful Tables of Weights and Measures," is now available. The 92-page publication, which proved so popular in the earlier edition, is a veritable storehouse of tables, charts, and formulae which the engineer will find invaluable. Included are: tables on sheet gage; relative sizes of ingots and forgings at various reductions; metric conversion tables; welding symbols; tables on hardness and temperature conversion; pipe sizes, dimensions and weights; trigonometric functions and formulae; electrical formulae; properties of metals and their approximate weights; properties of elements; and numerous other items of interest. In short, the booklet is a handy reference manuel for the engineer, putting a wealth of information at his fingertips.

(2) Graphite

The growing significance of graphite in electrometallurgy and electrochemistry is the subject of a bulletin published by the Electrode Division, Great Lakes Carbon Corp. The 16-page brochure explains briefly how performance is engineered into the particular chemical and physical properties of graphite required for each of its many end uses. Included also is a section on products of the company's electrode division.

(3) Refractories

A new 24-page data booklet describing super-refractories and cements has been issued by the Carborundum Co. In addition to figures on chemical analysis, thermal conductivity, specific heat, pyrometric cone equivalent, porosity, hot strength and other physical properties, the booklet discusses methods of manufacture and gives application information.

(4) Double Helical Gears

Information on specification, construction design, testing and various applications of double helical gears is published in a new bulletin by Worthington Corp. Also pictured in this booklet are diagrams, application charts listing dimensions in inches, as well as illustrations of parts such as gear and pinion, sleeve bearings, oil baffles and oil pump. (1958E)

(5) Sling Chains

A valuable reference for the buyer and user of sling chains has been published by the Columbus McKinnon Chain Corp. This 32-page booklet offers diagrams, charts and tables on standard and special styles of sling chains and attachments, and their sizes, weights and working load limits under many conditions of use. Presented in a well-illustrated easy-to-read format, the catalog includes the care, use, and ordering of sling chains. (No. 100)

(6) Sintering Equipment

A new bulletin on the design and construction of Dravo-Lurgi sintering, pelletizing and sinter cooling equipment has been published by Dravo Corp. The four-page bulletin, illustrates and briefly describes the process and equipment which incorporates time-tested improvements perfected during more than 40 years experience of Lurgi Gesellschaft fur Chemie und Huttenwesen, M.B.H., Frankfurt, Germany, in building sintering plants. (1503)

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53	AMERICAN WHEELABRATOR & EQUIPMENT CORP.	BULLETINS 894 AND 914	Descaling steel strip and sheet.
54	ASKANIA REGULATOR CO.	BULLETIN 115	Open hearth furnace control.
55	BAILEY METER CO.	SPEC. CA040	Control drives.
56	BAILEY METER CO.	SPEC. CA942B	Control linkage.
57	BEARINGS, INC.		Keystone Application manual.
58	BEDFORD FOUNDRY & MACHINE CO.		Crane catalog.
59	E. W. BLISS CO.	BULLETIN 40-A	Rolling mill brochure.
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61	CLEVELAND WORM AND GEAR CO.	BULLETIN K-100	Speed variator bulletin.
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67	ELECTRIC STORAGE BATTERY CO.	FORM 1982	Motive power batteries.
68	ENTERPRISE CO.	BULLETIN 502	Friction saws.
69	FOXBORO CO.	DATA SHEET AED 330-9	Hot blast temperature control.
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71	JOHNS-MANVILLE	PK-48A No. 7	Gaskets.
72	LINTERN CORP.	BULLETIN AC-549	Aire-rectifiers.
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74	MACKINTOSH-HEMPHILL	BULLETIN 55	Straight tubing problems.
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76	NATIONAL CARBON		Motor and generator maintenance.
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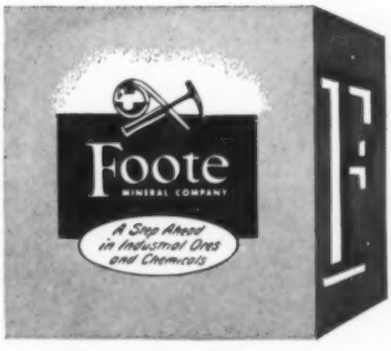
Better steels are the result of many things, not the least of which are addition agents. Although they may be small quantitatively, additives are extremely important qualitatively.

For many years, Foote Mineral Company has aided steel makers in materially improving both the quality of finished steel and the intermediate conditions involved in producing it. Manganese Sulphide and Rimex are two steel additives developed by Foote. Manganese Sulphide, for instance, provides a more practical and economical means of introducing manganese and sulphur into free-machining steels. Rimex, by producing a more vigorous rimming action, improves the quality of rim steels while reducing production costs.

Foote's highly specialized metallurgical engineering group is eager to work with steel producers to find means to improve both the economies and characteristics of metals for industry.

Write for information.

Product data sheets will be sent upon request.



FOOTE MINERAL COMPANY

443 Eighteen West Chelten Building, Philadelphia 44, Pa.

RESEARCH LABORATORIES: Berwyn, Pa. • PLANTS: Exton, Pa.; Kings Mountain, N.C.; Sunbright, Va.

How to cure a $1500-an-hour HEADACHE

You can't shut down an 80" hot strip mill for piggy-bank money. It costs about $1500 an hour to keep one going at full profit tilt.

So it's very important to keep a mill going—and a Trabon automatic lubrication system helps by delivering just the right amount of lubricant to each of the 4000 bearings in a typical mill at the right time. It does an absolutely foolproof job even when operating under dirt, steam, heat or any other rugged condition.

And all guesswork is eliminated, too. A single indicator at the pump tells you when each bearing has been properly lubricated.

Trabon systems, for oil or grease, have been delivering *positive* lubrication for over 25 years.

Write for more information today.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

Equipment News...

CIRCUIT BREAKER UNIT

▲ Announced by the General Electric Co. is a new type circuit breaker closing device which uses liquid carbon dioxide as the source of closing power.

The new device operates independently of the regular source of control or closing power in a station. It is portable and has adequate power to close the breaker against fault currents equal to its full momentary rating.

Designated the "Cooperator," the unit has a standard 10-lb bottle of carbon dioxide as a source for stored energy, a regulating valve, an intermediate receiver for holding the required amount of carbon dioxide gas for each closing operation at about 220 lb psi, a control valve which releases the gas from the intermediate receiver to close the breaker, and a power cylinder and piston for closing the circuit breaker arranged to be placed under the circuit breaker closing solenoid plunger.

Up to 75 closing operations are obtainable from a single standard bottle of liquid carbon dioxide. A reserve bottle is included to assure a full supply at all times.

The device will close all current designs of magne-blast circuit breakers in the interrupting range from 100 to 500 mva as used in both indoor and outdoor metal-clad switchgear.

The unit is a portable packaged power operator for closing oilless circuit breakers in metal-clad switchgear under actual operating conditions.

STRADDLE TRUCK

▲ A new 20,000-lb capacity straddle truck is available from Hyster Co. Used in the lumber industry originally, these straddle trucks are today used in other industries wherever heavy and bulky products are handled.

The versatile new unit, has a lifting capacity 20,000 lb. Power has been increased from 82 hp to 91 hp. Mechanical improvements include a 12-in. clutch, vacuum power brakes and heavy-duty hypoid differential. Additional new features are a positive controlled, simplified swing mechanism, new load shoes and link rods and a new instrument panel which includes an electric fuel gage as standard equipment. Package sizes are available up to a new maximum height of 78 in. or a new maximum width of 76 in.

SAFETY SWITCH

▲ Available from the Westinghouse Electric Corp. is a safety switch for heavy duty industrial use. This new switch features a dust-resisting enclosure and, for safety during maintenance, laminated plastic shields over the line terminals. Exceeding NEMA and government specifications, it is available in ratings from 30 to 1200 amperes, 600 volts and below.

Incorporation of the operating mechanism within the operating handle leaves the side gutters free from wiring. Copper parts are tinplated to prevent corrosion and oxidation and switch bases are coated with iron oxide cement to increase moisture resistance and dielectric strength. A neoprene gasket, compressed by truck-type cover latches, provides an effective cover seal.

PLASTIC COMPOUND

▲ A viscous, metal-filled plastic material which can be molded like putty to conform to almost any model or pattern and then hardnened to produce a precision replica of the original, has been developed by Industrial Development and Manufacturing Corp.

Known as "Plastik-Tul," the compound is especially applicable for making machining fixtures for odd and irregular shapes which ordinarily may be difficult to hold and/or position. It is spread over the pattern or poured into a form containing the pattern and allowed to harden.

During the hardening process "Plastik-Tul" requires no pressure and gives off no volatiles. When completely hardened, in accordance with furnished instructions, it is corrosion-resistant and is not affected by common cutting oils, solvents,

CUTTING FORGED SLABS FOR ATOMIC PROGRAM

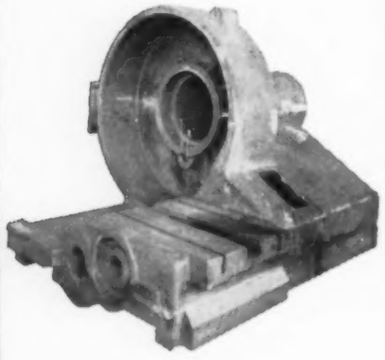
Guided by a templet tracer this Oxweld CM-23 oxy-acetylene flame-cutting machine slices an 18 x 108 x 65 in. section out of a king-sized carbon steel forging at the Isaacson Iron Works, Seattle, Wash. The rectangular-shaped slab was one of several in a rush order for the Hanford Atomic Energy Plant. It took less than two hours to make a total linear cut of 346 in. on each of the slabs, through the 18 in. depth.

Hyde Park

RED CIRCLE Rolls ALLOY-CHILLED

Gray Iron Castings

Castings of any size up to 80,000 pounds. Hyde Park facilities are equal to your every requirement



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Lathe Beds
Housings
Pinion Housings
Mill Housings
Shoe Plates
Layout Plates
Surface Plates

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS

greases, etc. It can be drilled, tapped, threaded, milled, broached, sawed, with ordinary metal-working tools and equipment. It may also be painted or plated.

The compound can be used for rapid and economical production of jigs, fixtures, plugs, gages, forming dies, holding fixtures, masking fixtures, etc. It is available in two types. Type 100 is highly viscous and may be applied with a putty knife, spatula, etc. to vertical surfaces. Type 200 is slightly more fluid and should be used when it is desirable to pour the material into a form surrounding the model or pattern to be duplicated.

Either type can be handled by inexperienced personnel and can be stored as shipped for approximately six months, under normal conditions, prior to the addition of the hardener.

STRIP GAGE

▲ Developed by the Reishauer Tool Works Ltd., Zurich, Switzerland, is a new continuous strip gage.

The entire gage system is built in one vertical axis, thus, gaging is free from parallaxis. The instrument provides functional operation since the light beam below zero indicates a thickness below nominal and vice versa. This reduces false operations of the screwdown.

The symmetrical housing of the gage head permits right hand or left hand mounting on the cross head. The top of the gage head can be rotated 180°, thus enabling to read the set basic thickness at choice from either the front or back of the gage head.

ELECTRIC HOIST

▲ A new heavy duty electric hoist has been designed by Northern Engineering Works, especially for use where the service is continuous and severe.

This new hoist is built in capacities from three to 15 tons, and is equipped with double four-wheel swiveled trucks to distribute the load on the supporting track and to reduce the wear on truck wheels and track. Both hoist and trolley travel are controlled either by a pendant push button or from an attached operator's cab. Heavy duty a-c or d-c motors

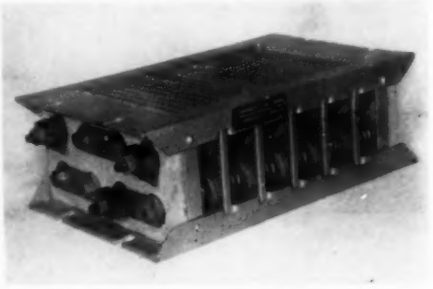
GUYAN
RESISTORS

Engineered and designed to eliminate resistor maintenance on troublesome mill applications.

Non-breakable helical coil construction ends burnouts due to warping and buckling of grids.

Sturdy, rugged steel construction eliminates shock and vibration troubles.

Custom designed for your conditions including excessive graphite accumulations.



With a quarter century of resistor engineering, we invite you to take advantage of our experience.

For complete information on Guyan Resistors, please contact the nearby Guyan Representative or our main plant at Logan, W. Va.

Baltimore, Md.—Durling Electric Co., 2505 St. Paul St.

Birmingham, Ala.—Ebbert & Kirkman Co., 2313 6th Ave. So.

Buffalo, N.Y.—Buffalo Electric Co. West Mohawk St.

Chicago, Ill.—John K. Byrne, 1515 W. Howard St.

Cleveland, Ohio—H. V. Varney Co., 625 Engineers Bldg.

Detroit, Mich.—Plant Equipment Co., General Motors Bldg.

Philadelphia, Pa.—George I. Wright 811 Commercial Trust Bldg.

Pittsburgh 27, Pa.—P. R. Holden, 1602 Parkline Drive.

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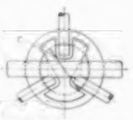
Corrugating and Complete Line of Culvert Equipment—Slitting and Coiling Equipment for Ferrous and Non-Ferrous Material in All Capacities—Warehouse and Steel Mill Cut to Length Lines for Shearing and Levelling Sheets from Coils—Shears for Shearing Sheets and Plates Both Underdriven and Overdriven Types in all Capacities up to 1¼" plate.

STAMCO, Inc., New Bremen, Ohio

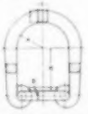
New **TM ALLOY STEEL** downtown
MAGNET CHAIN
lasts 5 to 15 times longer than conventional types!

- Locating plate keeps legs at 120° centers—eliminates wear—increases life of assembly!
- Made of Taylor Made Alloy Steel Chain—has twice the tensile strength of wrought iron.
- Resistant to shock, grain-growth, work-hardness.

Patent No. 2626175



Locating Plate takes larger joiner links with squared top sections—keeps chain legs separated at 120° centers to reduce friction, twisting and gouging.



New Lifting Bail provides larger opening for hook. Heavy, squared-type Alloy Steel construction assures longer life.

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S. G. TAYLOR CHAIN CO., Dept. H, Hammond, Ind.

The Jones and Laughlin Steel Corporation uses four Gleason Reels for remote control on each of the two shear gauges of the PI-10" Bar Mill in their Pittsburgh Works. Two SHO-102 overhung cable reels shown on the left permit remote control of the travel motors which drive the two traverses. Two LA-76 air hose reels (one out of sight) permit remote control of the gauge stops. Gleason makes a complete line of spring and motor driven reels in all sizes and capacities. Write for complete details.

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Subsidiary of Maysteel Products, Inc.
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NOW... WIRE or STRINGY SCRAP

- **HANDLED**
- **STORED**
- **BUNDLED WITH EASE!**

WITH THE *NEW*
Phillips SCRAP BALLER

If you have a problem of balling stringy scrap or wire—you can't afford to be without this new Phillips Scrap Baller. It balls scrap into compact cylinders 22" to 28" in diameter weighing from 200 to 700 lbs., depending on metal—which can be sold as No. 1 Melting Scrap. Investigate today!

Scrap is drawn into the balling chamber—and is quickly shaped into compact cylinder which rolls from machine when released.

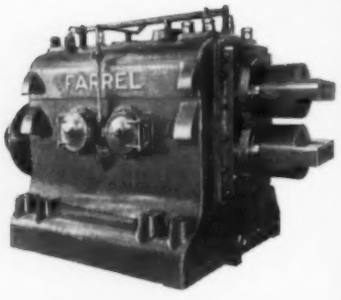
Write for Bulletin E-52.

Phillips
CORPORATION

(formerly Phillips Mine & Mill Supply Co.)
Manufacturers Since 1863
18 Arch Street, Carnegie, Pa.

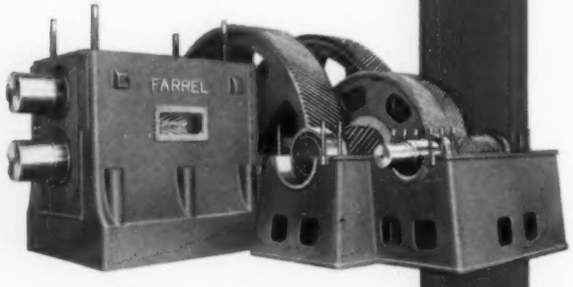
5500 HP GEAR DRIVE

Herringbone-geared reduction unit designed to transmit power to a 134" three-high, sheared plate mill, reducing motor speed from 375 to 70.35 RPM.



2000 HP PINION STAND

21" pinion stand designed to transmit power to a four-high aluminum sheet mill. The heat-treated, forged steel pinions are continuous-tooth herringbone, generated by the Farrel-Sykes process.



2000 HP COMBINATION UNIT

Built to transmit power to a two-high, cold brass, breakdown mill, this combined drive and pinion stand has first reduction gears and mill pinions of the Farrel-Sykes herringbone type, while the second reduction gears are split (divided) double helical.

Every FARREL MILL DRIVE is individually designed

Power and speed, type and gauge of metal to be rolled, process (hot or cold), nature of load (continuous or intermittent), type of drive motor—all are taken into account before the size, material and type of construction are specified.

This development of a Farrel unit, whether it is a gear drive, pinion stand, or combination, assures optimum efficiency, plus the inherent strength to withstand the shocks, stresses and wear encountered in continuous, heavy-duty service.

Herringbone, single helical, or a combination of single and double helical gears may be furnished for gear drives. Mill pinions are usually herringbone type, although single helical pinions can be supplied. These gears and pinions are precision-generated by the famous Farrel-Sykes process, assuring accuracy of tooth spacing, profile and helix angle, resulting in high efficiency, and smooth, quiet operation.

Send today for information on these individually engineered mill drives. Or, if you prefer, a Farrel engineer will be glad to discuss your drive problems with you.

FARREL-BIRMINGHAM COMPANY, INC.
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Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N.Y.
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FB-990

Farrel-Birmingham ®

and full magnetic control are furnished.

The billet is designed with an all-steel frame, heavy duty roller bearings, hardened steel gears, large drum and sheaves.

SPRAY NOZZLES

▲ A new complete line of industrial spray nozzles has been introduced by Spraying Systems Co.

This new group is identified as the 15 degree Injector type Fulljet Nozzles. The smallest nozzle in this group is a little under 1¾-in. long with a capacity of 1.5 gpm at 10 psi. The largest is almost 17-in. long, with a capacity of 1108 gpm at 100 psi.

At 40 lb pressure all of these nozzles have a spray angle of 15 degrees. Because of the relatively narrow spray angle, the spray is delivered at medium high impact and is useful in a variety of industrial and chemical field applications where a combination of heavier impact, fairly compact full cone spray, and wide choice of capacities is desired.

Book Reviews . . .

▲ **"Alloy Steels Pay Off,"** a publication of the Climax Molybdenum Co., 500 Fifth Avenue, New York 36, N. Y. was written and designed as an aid to engineers, financial and operating men. It discusses alloy steels as a class, portraying over-all benefits which may be obtained by

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U S G Grade 223 Brush for DC crane motors with Statite*

U S G Grade 550 Brush for AC Crane Motor Rings

197

*Permanent shunt connection, needing no hammerclips; cannot be jarred loose or pulled out.

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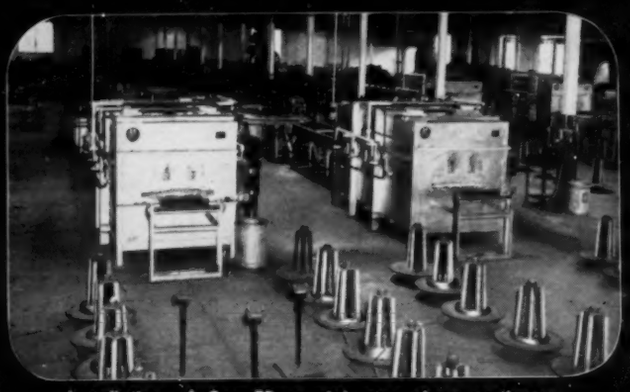
EF Furnaces for Bright Annealing and Normalizing ---- Continuously



Installation of five EF special atmosphere continuous furnaces bright annealing stainless steel wire.

For Wire, Tubing, Strip and other Products

3000 lbs. of steel tubing, per hour, are bright normalized in this EF gas-fired radiant tube type special atmosphere furnace.

We are in position to design, build and put in operation: continuous equipment for hot or cold rolled, high or low carbon, stainless, silicon, tinplate, aluminum, brass, bronze or any other ferrous or non-ferrous metal—for bright annealing, normalizing, galvanizing, aluminizing, tinning or any other process—in the size and type best suited to your plant, process, product or production requirements. No job is too large or too unusual.

Put your production furnace problems up to experienced engineers—*it pays.*

THE ELECTRIC FURNACE CO.

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Gas Fired, Oil Fired and Electric Furnaces

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A large capacity continuous strip normalizing, annealing and galvanizing unit. This is a combination EF gas fired radiant tube and electrically heated installation

replacement of carbon steel with a suitable alloy steel. In this book, the writers have attempted to illustrate some of the changes in economic factors that have made alloy steels increasingly more price-worthy and to present some actual cases where the adoption of alloy steel has saved money for the producer of the finished parts, or the user, or both. It indicates the general benefits, including greater pay load, lower operating costs, longer life, greater safety and less maintenance which may result from the replacement of carbon steel with a properly chosen alloy steel. Free copies are available to those who write to the Climax Molybdenum Co. at the above address, on their business letterheads.

▲ **"Metal Statistics 1954,"** was published by the American Metal Market Co., 18 Cliff Street, New York 38, N. Y. in a handy pocket-size reference book form, 4 × 6-in., containing 848 pp, cloth bound, price $3.00. This book contains up-to-date and historical records of production, consumption, stocks, imports and exports, monthly and annual market price averages plus informative material on miscellaneous economic subjects with data usually through 1953. This is the 47th annual edition of this widely used reference guide.

▲ **"Standard Metal Directory,"** the 1954 edition, was recently published by the Bardeen Press, 425 West 25th Street, New York City 1, N. Y. It contains 900 pp, 5½ × 9-in., cloth bound, price $15.00. This 1954 edition has been enlarged, and completely revised with two new important features added. The directory has four sections; namely, iron and steel plants; ferrous and non-ferrous metal foundries; metal rolling mills; smelters of non-ferrous metals. It has listed more than 10,000 detailed reports on various steel mills, foundries, smelters, rolling mills and non-ferrous metal plants throughout the United States and Canada. The plants are listed both geographically and alphabetically, and the reports give the name of the company, its capitalization, plant equipment, products manufacturer, primary and secondary

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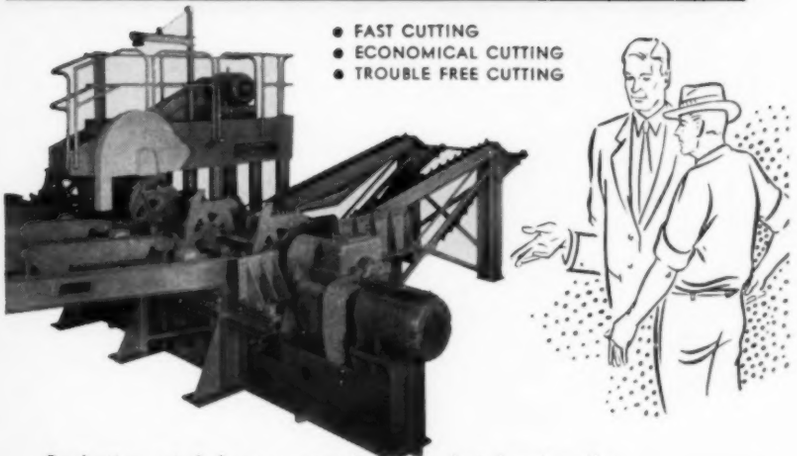
MILL TYPE
FRICTION SAW



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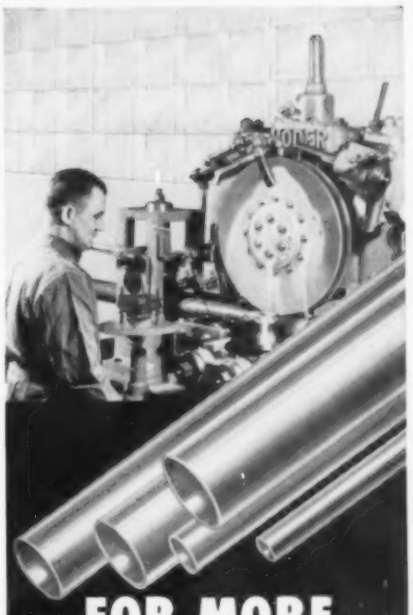

FOR MORE PROFITABLE TUBE MAKING

• Nearly two decades ago Yoder introduced a line of tube mills equipped with their revolutionary new rotating welding transformer. To the high quality and low cost production of these mills, is due much of the credit for the big and rapidly expanding demand for E-W (electric welded) tubing.

Now as then, what the motor is to the automobile, the welder is to the tube mill. Through persistent research, tests and experiments, Yoder welders have been further improved and epoch-making new types developed:

1. ***For Steel Pipe and Tubing*** from ½" to 24" dia. Yoder "Four-in-One" resistance welder, most compact, trouble-free and efficient yet designed for tube production.
2. ***For Steel Pipe and Tubing up to 4-in. dia.*** new Yoder-Tocco Induction Welder. Speeds as high as 250 f.p.m.
3. ***For Aluminum, Brass, Nickel and other*** non-ferrous metals and alloys, new High-Frequency R. F. Welders. These Yoder mills are especially economical for light and medium heavy gauges.

Further information about tube making by any of these methods, literature, consultations and estimates are yours for the asking.

THE YODER COMPANY
5495 Walworth Ave., Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

Electric Weld
TUBE MILLS

raw materials consumed, names of company officials, purchasing agent and sales manager. The two new features therein are a list of distributors of non-ferrous metal products in the United States and Canada, plus a list of smelters and refiners of non-ferrous metals throughout Europe. It contains numerous special lists covering plants of all types. The directory is a valuable reference for those who are engaged in any branch of steel, or metal industries and to purchasing agents and manufacturers.

▲ **"Procedures in Experimental Metallurgy,"** by A. U. Seybolt and J. E. Burke, 340 pp, 6 x 9-in., cloth bound, price $7.00 was published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. It is the primary aim of this book to describe most of the important laboratory techniques which are now used in preparation of metals and alloy specimens for further study. It is well written so anyone familiar with physical and chemical principles can carry out the unit operations described. The preparation of metal samples to the point of making observations on the properties of the metal is the guiding principle or theme of this book. The chapters are written in the order of natural sequence of events that occur in the laboratory such as: melting, casting, fabrication, and heat treatment.

▲ **"Vibration Problems in Engineering,"** a third edition by S. Timoshenko, was recently published by the D. Van Nostrand Co., Inc., 250 Fourth Avenue, New York, N. Y. This new edition reflects the latest information on the subject dealing with the fundamentals of vibration theory and their application to the solution of many technical problems. It offers an anaiysis of these problems which continue to be of increasing importance in mechanical engineering design. It covers areas of investigation from the balancing of machines, the torsional vibration of shafts and geared systems, to the vibration of turbine blades and discs, railway track and bridges, and foundations. There are discussions on new methods and expanded material on non-linear vibration plus new topics such as combined bending and torsional vibration of beams. The book contains 468 pp, 6 x 9-in., cloth bound, and sells for $8.75.

▲ **"Engineering Metallurgy,"** by Dr. E. M. H. Lips, 250 pp, 6 × 9 in., cloth bound, price $6.25 was recently published by N. V. Philips', Eindhoven, Holland, as a unit in the Philips Technical Library. Metallurgy is covered in this book essentially for the practical engineer. It covers properties of new materials and has late data on the more familiar ones. Distributor in the United States is Elsevier Press, Inc., 155 East 82nd St., New York 28, N. Y.

▲ **"Product Directory of the Refractories Industry in the United States"** was just published by the Refractories Institute. This volume lists over 2000 brand names produced by 159 refractory manufacturers. The Directory is cross indexed for ready reference by companies, plant locations, product divisions and brand names. Copies of the Directory may be secured at $2.00 each from the Refractories Institute, First National Bank Building, Pittsburgh, Pa.

(*Please turn to page 204*)

FAST···LEGIBLE BILLET MARKING!

now made possible with the *NEW*

Pneumatic BILLET MARKER

This new, compact unit stamps ends of billets 4" x 4" or larger with a deep, legible mark as shown above. Unit is mounted on an I-beam track and powered by heavy duty air cylinder. Quick change type holder is kept in stamping position at all times without special guides.

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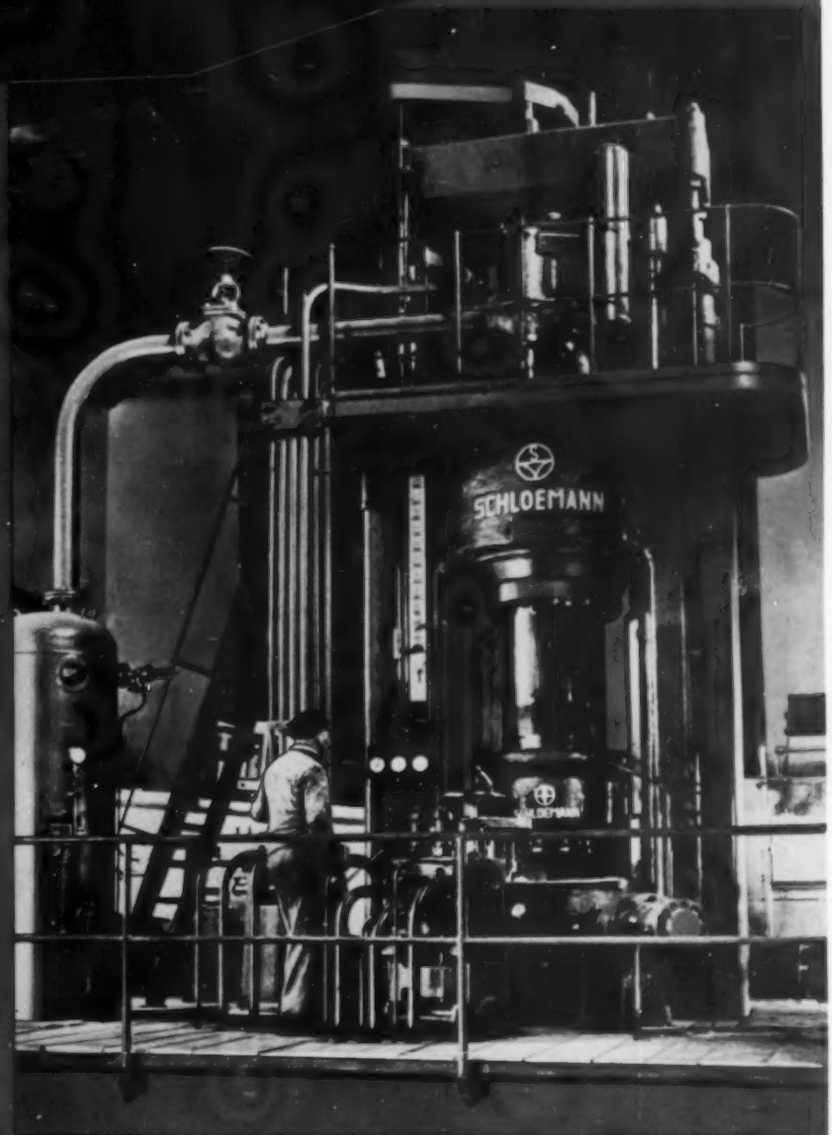

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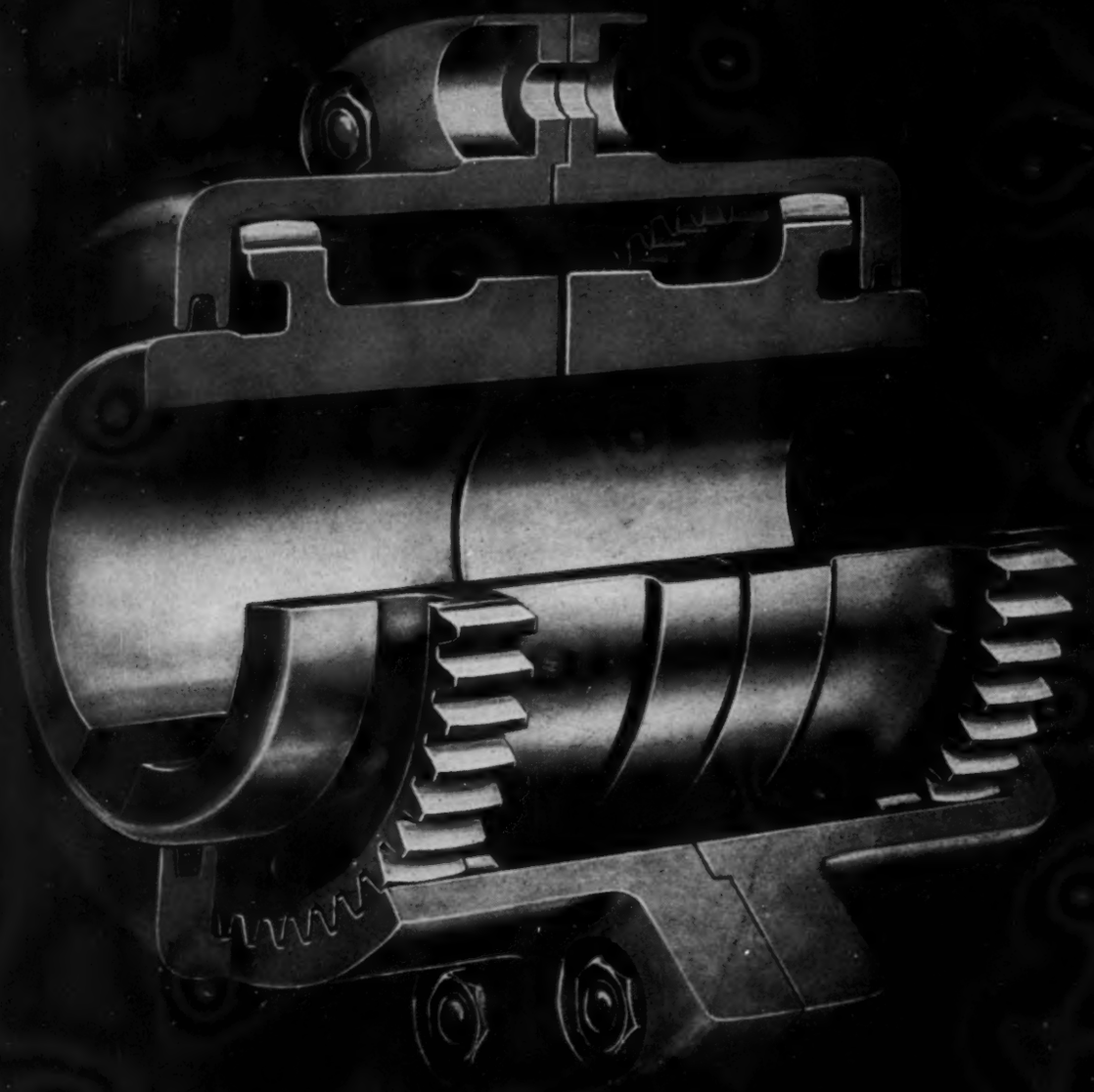

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If you agree with Mr. Homer that ". . . the Payroll Savings Plan is one of the easiest ways to save for economic security."—

If you believe with millions of other Americans that there is no safer investment than U.S. Savings Bonds—

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Pick up the phone, now, and ask the man in charge of your Payroll Savings Plan three questions:

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If less than 50% of your employees are enrolled in the Plan . . . if you have not conducted a person-to-person canvass in the past two years *(or if you do not have the Plan)*, act now! Telephone, wire or write to Savings Bonds Division, U.S. Treasury Department, Washington, D. C. You will hear promptly from your State Director, U.S. Treasury Department who will be glad to help you conduct a person-to-person canvass that will put an application blank in the hands of every employee. That is all you have to do. Your employees will do the rest. They want to save for their economic security.

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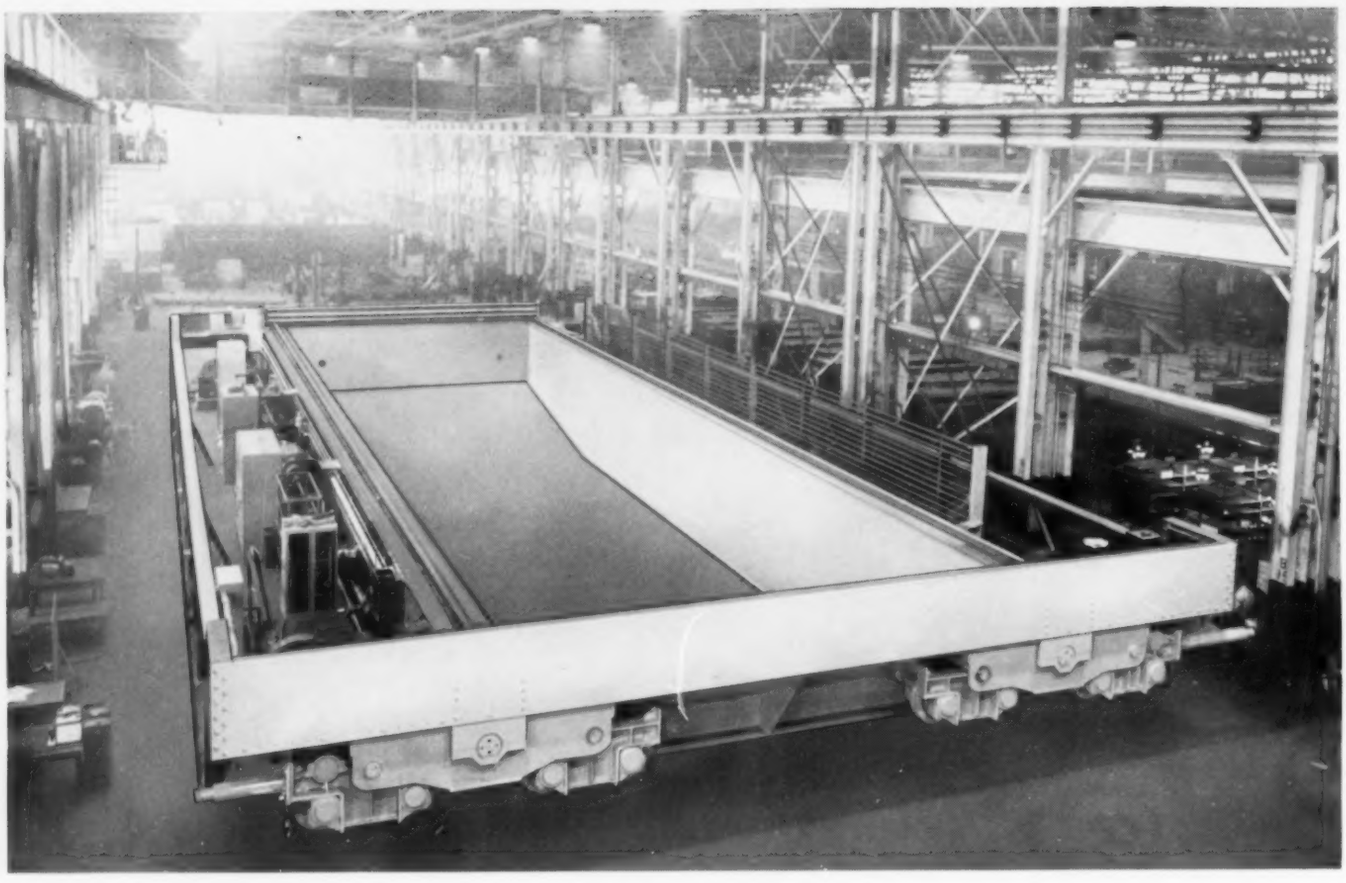


CRANES TO A.I.S.E. SPECIFICATIONS No. 6....

by "Shaw-Box"

Since the issuance of A.I.S.E. Standard Specifications No. 6 covering steel mill cranes, "Shaw-Box" has built many cranes ranging from 10 to 200-tons to these specifications. The above illustration, showing a 175-ton capacity bridge 80'-0" span with double bridge drive and double equalized trucks, is typical of their interpretation of these specifications.

In "Shaw-Box" Steel Mill Cranes, whether built to A.I.S.E. Specifications or your own, you get the added advantages that come from the experience gained in more than 65 years of building exclusively overhead load-handling equipment, plus "Shaw-Box" engineering, fine workmanship, and precision manufacturing methods. You also obtain today's greatest value in steel mill cranes.

SEND ALL YOUR INQUIRIES FOR STEEL MILL CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.
Muskegon, Michigan

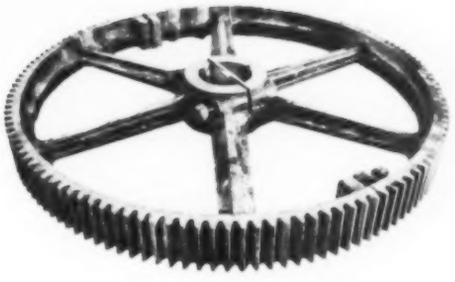
Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' and 'American-Microsen' Industrial Instruments, and Aircraft Products.

FAST REPAIRS OF HEAVY PARTS with THERMIT

- **Cuts downtime**
- **Eliminates costly replacement**
- **Repair outlasts original unit**

Thermit is used extensively for pinion gear repair.

Heavy machine frame repaired by Thermit Welding.



Crankshaft, 8" in diameter, was restored to duty by Thermit after being broken.

3 fractures in this large ring gear were quickly repaired by Thermit Welding.

When industrial equipment breaks down, the most important problem is to get it back in service—and FAST! Thermit Welding has answered this need time and again . . . in a variety of plants . . . for a variety of parts. Thermit requires a minimum of technical skill . . . gives consistently sound welds . . . is more economical than part replacement. Thermit repairs are permanent repairs.

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this man has ice water in his veins!

Of course he'd never volunteer to give blood, anyway. But any resemblance of this old duffer to the average, red-blooded American is a mistake.

For instance, several million healthy Americans have given blood. *But it's not enough.*

So this is to tell several million more Americans that their blood is needed—now!

We've never let anyone down who was in trouble. When a GI gets wounded and suffers *shock*—he's in bad trouble. He's got to have blood and lots of it! Folks here at home need blood too—to save their lives.

So make a date with your Red Cross, Armed Forces or Community Blood Donor Center. *One* hour and you're on your way.

BUSINESS EXECUTIVES CHECK THESE QUESTIONS

If you can answer "yes" to most of them, you—and your company—are doing a needed job for the National Blood Program.

- ◯ HAVE YOU GIVEN YOUR EMPLOYEES TIME OFF TO MAKE BLOOD DONATIONS?
- ◯ HAS YOUR MANAGEMENT ENDORSED THE LOCAL BLOOD DONOR PROGRAM?
- ◯ HAS YOUR COMPANY GIVEN ANY RECOGNITION TO DONORS?
- ◯ HAVE YOU INFORMED EMPLOYEES OF YOUR COMPANY'S PLAN OF CO-OPERATION?
- ◯ DO YOU HAVE A BLOOD DONOR HONOR ROLL IN YOUR COMPANY?
- ◯ WAS THIS INFORMATION GIVEN THROUGH PLANT BULLETIN OR HOUSE MAGAZINE?
- ◯ HAVE YOU ARRANGED TO HAVE A BLOODMOBILE MAKE REGULAR VISITS?
- ◯ HAVE YOU CONDUCTED A DONOR PLEDGE CAMPAIGN IN YOUR COMPANY?
- ◯ HAVE YOU SET UP A LIST OF VOLUNTEERS SO THAT EFFICIENT PLANS CAN BE MADE FOR SCHEDULING DONORS?

Remember, as long as a **single** pint of blood may mean the difference between life and death for **any** American . . the need for blood is **urgent**!

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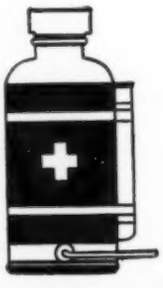

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BOOK REVIEWS

(*Continued from page 196*)

▲ **"Simplified Design of Structural Steel,"** has just been published in a second edition by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y., 244 pp, 5 × 8-in., cloth bound, $5.75. This book was written to bring up to date the first edition which was published in 1945. It contains a revision giving the discontinued and new shapes, modifications, new formulas, new working stresses and design procedures which have been advanced. This new edition contains revised tables of properties, and presents discussions and illustrative examples which have been modified in accordance with current specifications and unit stresses. Many new safe load tables have been added.

▲ **"Magnetic Control of Industrial Motors,"** by Gerhart W. Heumann, second edition, 714 pp, cloth bound, 6 × 9-in., price $9.50 has just been published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Many changes in the design of control components and systems have taken place since the first edition of this book which are reflected in this second edition. It includes new material on adjustable voltage and regulating systems, particularly with regard to rotating and magnetic amplifiers. Care has been taken to discuss the external performance characteristics of all types of industrial motors. Following this is a discussion of components and devices available to the designer. This book is helpful in selecting quickly and accurately the proper type of controller for a given application.

▲ **"Sonics,"** by Theodor F. Heuter and Richard H. Bolt was just published by John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Book contains 456 pp., 6 x 9-in., cloth bound, and sells for $10.00. This book presents a thorough, practical presentation of the principles and practices in uses of sound waves in engineering and science, from audible sounds to ultrasonics. This book has drawn upon material from physics, engineering and electronics relating to the fundamental physics of vibration and sound, design principles of electroacoustic and fluid-dynamic transducers, choice of sonic variables for systems engineering, and special techniques for testing and processing. Great emphasis has been placed on the techniques and instrumentation for accomplishing actual tasks. A knowledge of mathematics is necessary for best use of the book.

▲ **"FBI Register of British Manufacturers,"** is published annually around November. This register is the authorized directory which provides a comprehensive reference to all sections of British industry. Book may be obtained from Iliffe & Sons, Ltd., Dorset House, Stamford St., London SE 1, England, 7 × 9½ in., 852 pp, cloth bound, prepublication price $4.50.

▲ **"Matter Energy Mechanics,"** by Dr. Jakob Mandelker, 73 pp, 6 × 9-in., cloth bound, price $3.75 was recently published by the Philosophical Library, 15 East 40th Street, New York 16, N. Y. This book is based on energy concept of matter and introduces a new kinetic energy formula to unify and extend relativity mechanics on the principle that the motion of a body whose mass increases with velocity is equivalent to motion with resistance.

▲ **"Father of Air Conditioning,"** by Margaret Ingels was recently published by Country Life Press, Garden City, N. Y., 170 pp, 5½ × 8½-in., price $2.50. Book is also from Carrier Corp., Dept. PR 3, 300 South Geddes Street, Syracuse, N. Y. The author depicts the life of the late Dr. Willis H. Carrier, the founder of his company. It contains also a comprehensive chronological table covering the period 1500 to 1952 of events which led to modern air conditioning.

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EXTRA PROTECTION
in corrosive
atmospheres

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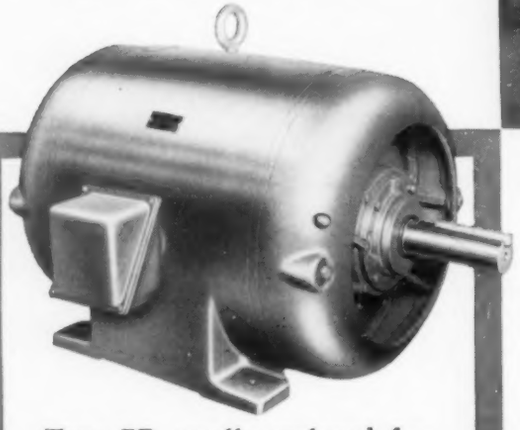
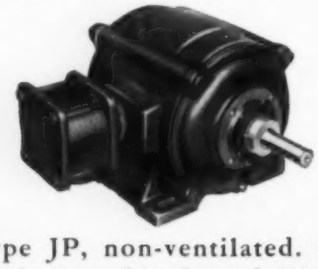


Type EP, totally-enclosed fan-cooled. Available in ratings from 2 to 250 hp.



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M55-7

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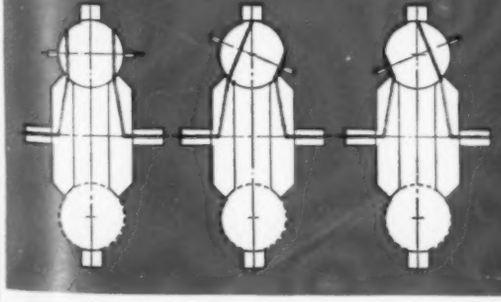

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axles on which the balls rotate (see diagrams, left, and cutaway view, right).

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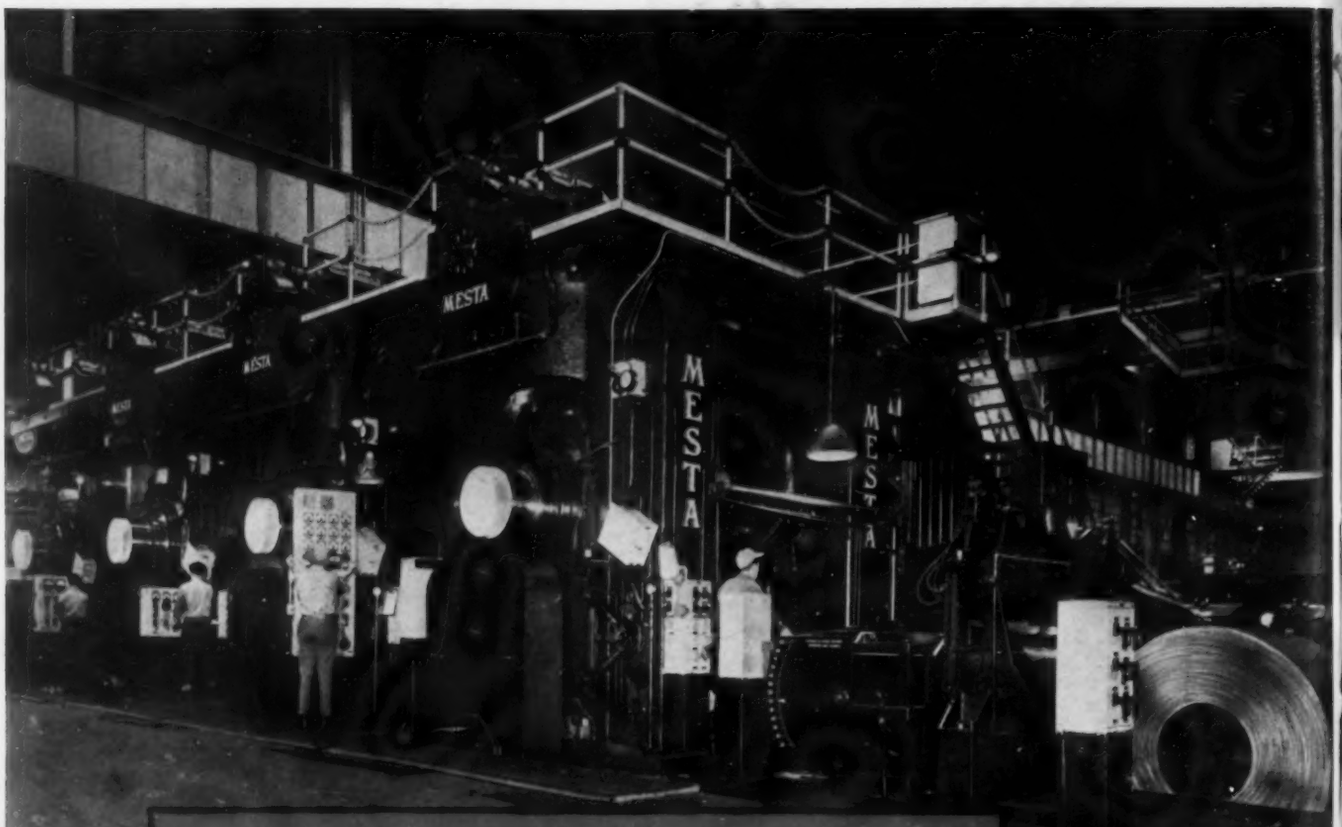

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